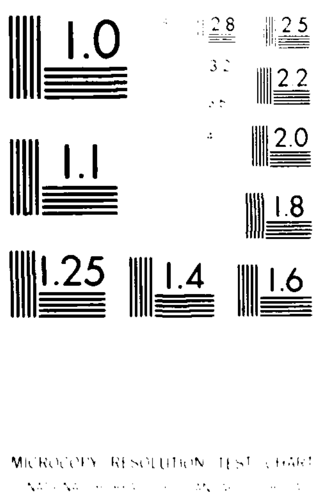
AD-A113 118 ERTEC WESTERN INC LONG BEACH CA F/G 8/7
AGGREGATE RESOURCES STUDY GARDEN AND COAL VALLEYS, NEVADA.(U)
JUL 81 F04704-80-C-0006
UNCLASSIFIED E-TR-37-I NL

2 of 2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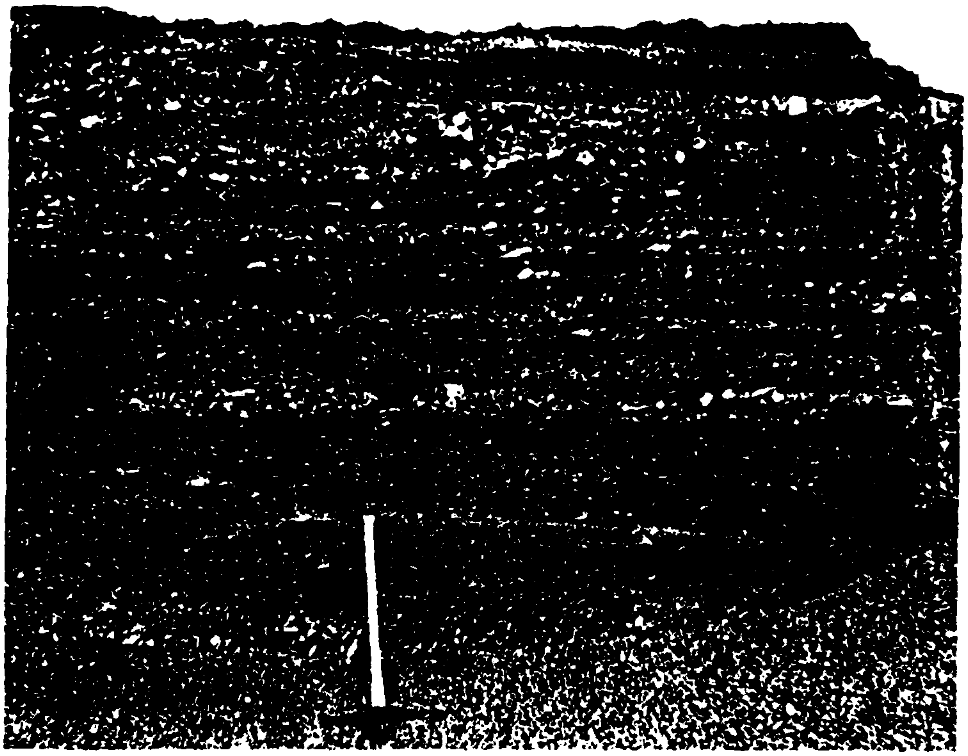
APPENDIX D

GARDEN AND COAL VALLEYS, STUDY AREA PHOTOGRAPHS



Alluvial Fan Deposit (Aafg) in western Garden Valley; Class I coarse/Class II fine aggregate source (Station 22).

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GARDEN AND COAL VALLEYS
STUDY AREA PHOTOGRAPH

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FIGURE D-1

Older Lacrustrine Shoreline Deposit (Aolg) in west central Coal Valley; Class I coarse and fine (multiple) aggregate source (Station 54).

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GARDEN AND COAL VALLEYS
STUDY AREA PHOTOGRAPH

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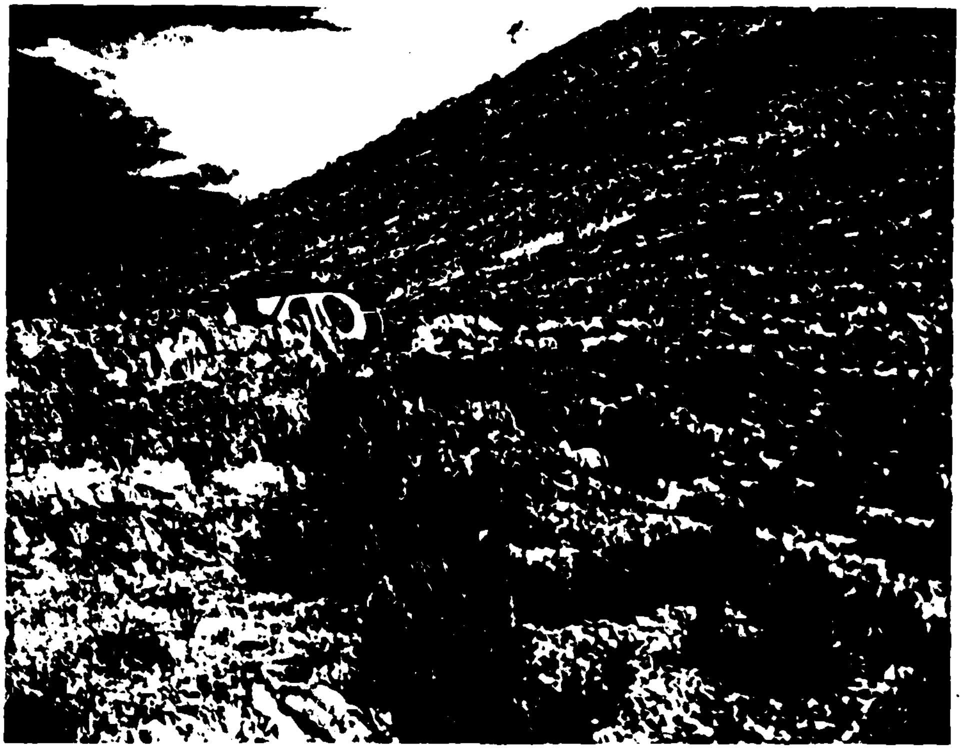
FIGURE D-2

Alluvial Fan Deposit (Aafs) in east central Coal Valley; Class II fine aggregate source (Station 61).



Guilmette Formation (Cau) in foreground with Joana Limestone (Ls) on hill in background, southern Seaman Range; Guilmette was sampled here and is a Class I crushed rock aggregate source (Station 49).

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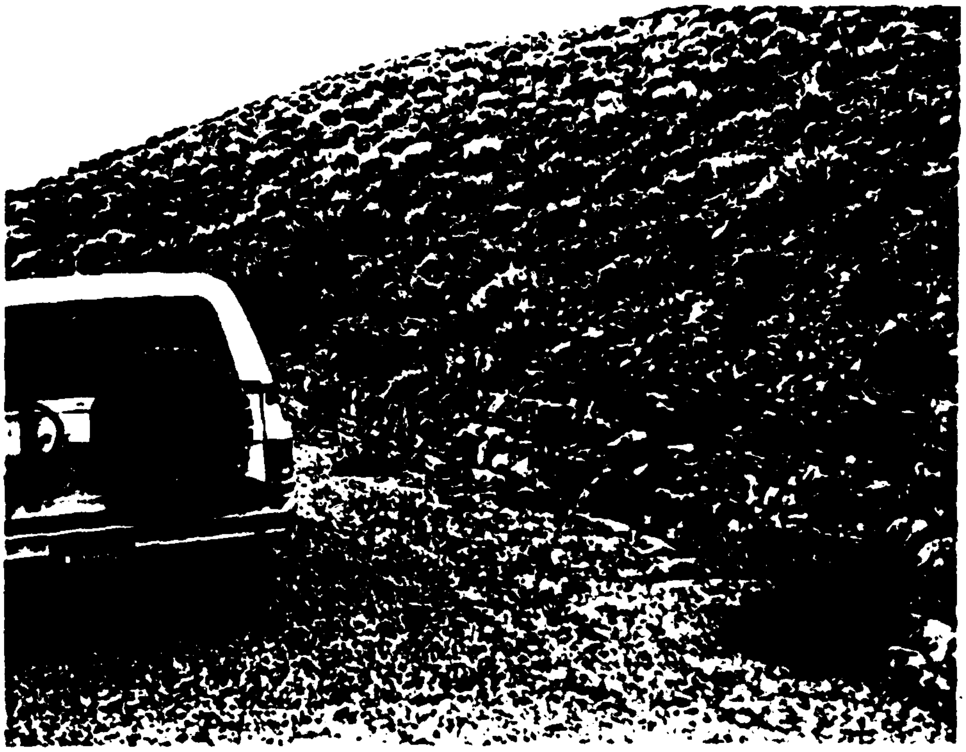
GARDEN AND COAL VALLEYS
STUDY AREA PHOTOGRAPH

2 JUL 81 FIGURE D-4



Joana Limestone (Ls) in Golden Gate Range; Class I crushed rock aggregate source (Station 8).

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STUDY AREA PHOTOGRAPH

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FIGURE D-5

APPENDIX E

ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

AGGREGATE RESOURCES GEOLOGIC UNIT SYMBOLS		ERTEC WESTERN GENERAL GEOLOGIC UNIT EXPLANATION
		ROCK
		Shown in regions where rock is exposed, the areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur the predominant rock type is shown followed by the subordinate rock type (e.g. S_{3p}/I_{4r}). Rock may be subdivided into bedrock [R].
	I	IGNEOUS (UNDIFFERENTIATED): Rocks formed by solidification of a molten or partially molten mass
Gr	I_1	Intrusive: Plutonic rocks formed by solidification of molten material beneath the surface (e.g. granite, granodiorite, diorite, gabbro)
Vu	I_2	Extrusive (intermediate and acidic): Volcanic rocks of intermediate and acidic composition formed by solidification of molten material at or near the surface (e.g. rhyolite, latite, dacite, andesite)
Vb	I_3	Extrusive (basic): Volcanic rocks of basic composition generally formed by solidification of molten materials at or near the surface (e.g. basalt)
Vu	I_4	Extrusive (pyroclastic): Rocks formed by accumulation of volcanic ejecta (e.g. ash, tuff, welded tuff, agglomerate)
Su	S	SEDIMENTARY (UNDIFFERENTIATED): Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals
Su, Qtz	S_1	Arenaceous and/or Siliceous Rocks: Composed of sand size particles (e.g. sandstone, orthoquartzite) or of cryptocrystalline silica (e.g. opal, chert)
Ls, Do, Cau	S_2	Carbonate Rocks: Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g. limestone, dolomite, chalk)
	S_3	Argillaceous Rocks: Composed of clay and silt-sized particles (e.g. siltstone, shale, claystone)
	S_4	Evaporite Rocks: Precipitated from solution as a result of evaporation (e.g. halite, gypsum, anhydrite, sylvite)
Su	S_5	Coarse Clastic Rocks: Composed of gravel-sized or larger clasts (e.g. conglomerate, breccia)
Mu	M	METAMORPHIC (UNDIFFERENTIATED): Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure
Mu	M_1	Coarse grained: rocks formed by higher-grade regional metamorphism, either banded or granular (e.g. gneiss, granulite, amphibolite)
Mu	M_2	Fine grained: schistose rocks formed by lower grade regional metamorphism (e.g. schist, slate, phyllite)
Mu	M_3	Nonfoliated: rocks formed chiefly by contact metamorphism (e.g. hornfels, marble)
Qtz	M_4	Metaquartzite: rocks formed by metamorphism of highly siliceous rocks
		BASIN-FILL
	A	BASIN-FILL DEPOSITS: Fine- to coarse-grained materials deposited principally by wind, water or gravity
Aal	A_1	Younger Fluvial Deposits: Major modern stream channel and flood-plain deposits
Au, Aal	A_2	Older Fluvial Deposits: Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages
Au	A_3	Eolian Deposits: Wind-blown deposits of sand occurring as either thin sheets (A_{3s}) or dunes (A_{3d})
Aol	A_4	Playa and Lacustrine Deposits: Deposits occurring in modern, active playas (A_4) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes (A_{4o})
Aaf	A_5	Alluvial Fan Deposits: Alluvial deposits consisting of debris flow and water-laid alluvium near mountain fronts, grading into predominantly water-laid alluvium deposited in shifting distributary channels near the basin center. Younger (A_{5y}), intermediate (A_{5i}) and older (A_{5o}) alluvial fans are differentiated by surface soil development, terrain conditions and present depositional/erosional environment
Au	A_3/A_5	Mixed non-rock units: Most areally extensive unit is listed first
Aaf	A_{5y} (A_{5i})	Parenthetic unit underlies thin veneer of overlying mapped unit

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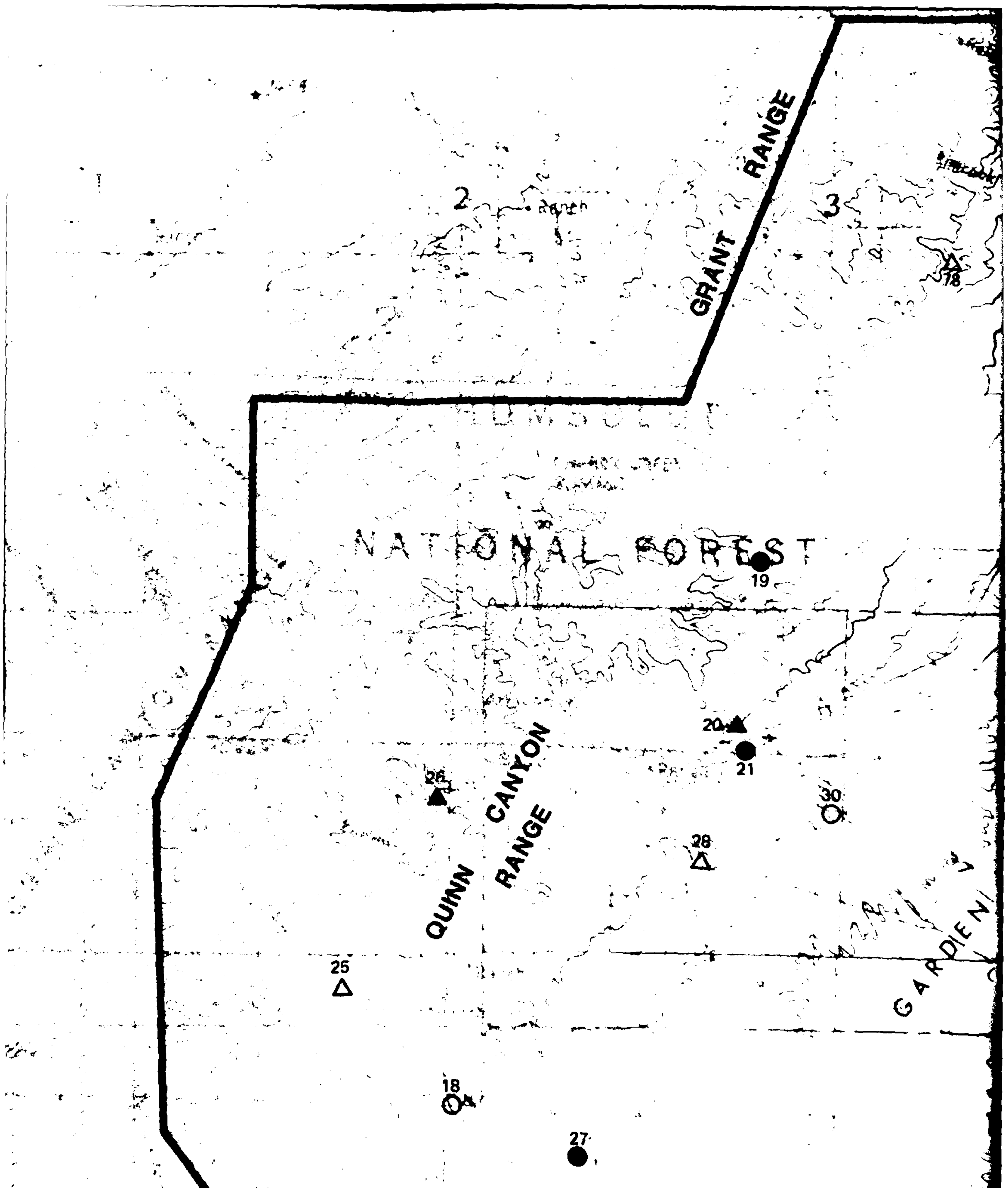
ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

2 JUL 81 APPENDIX E



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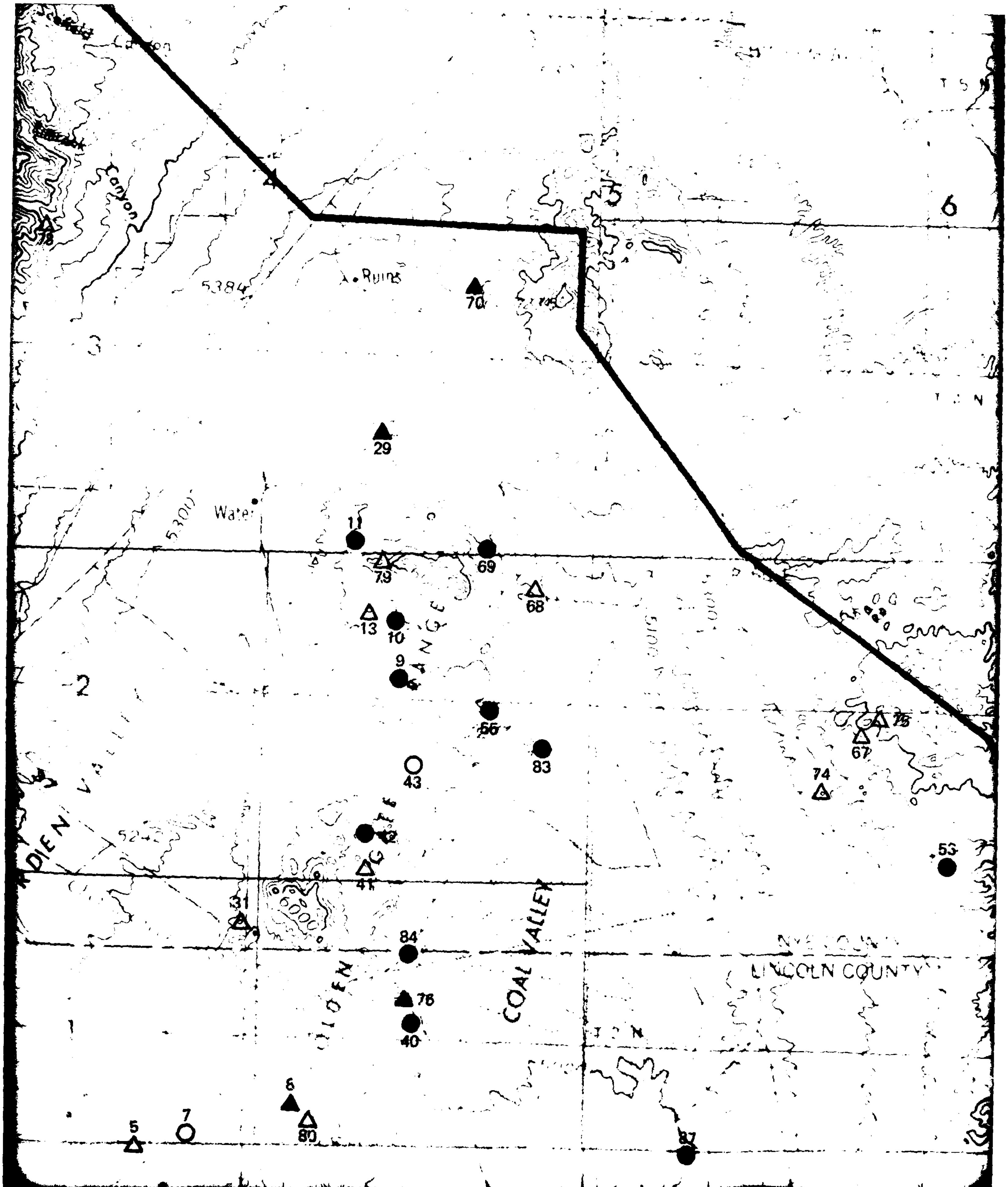
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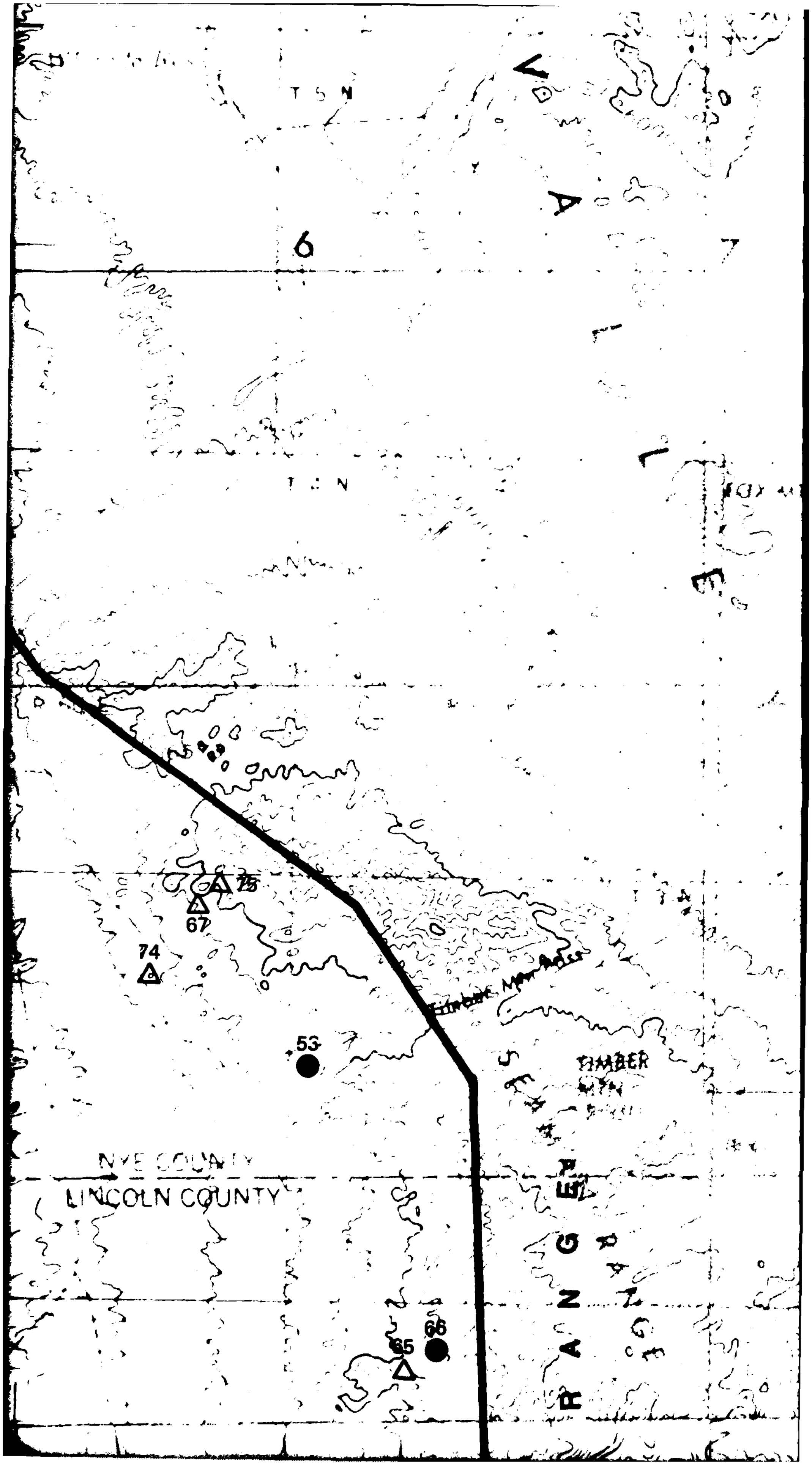

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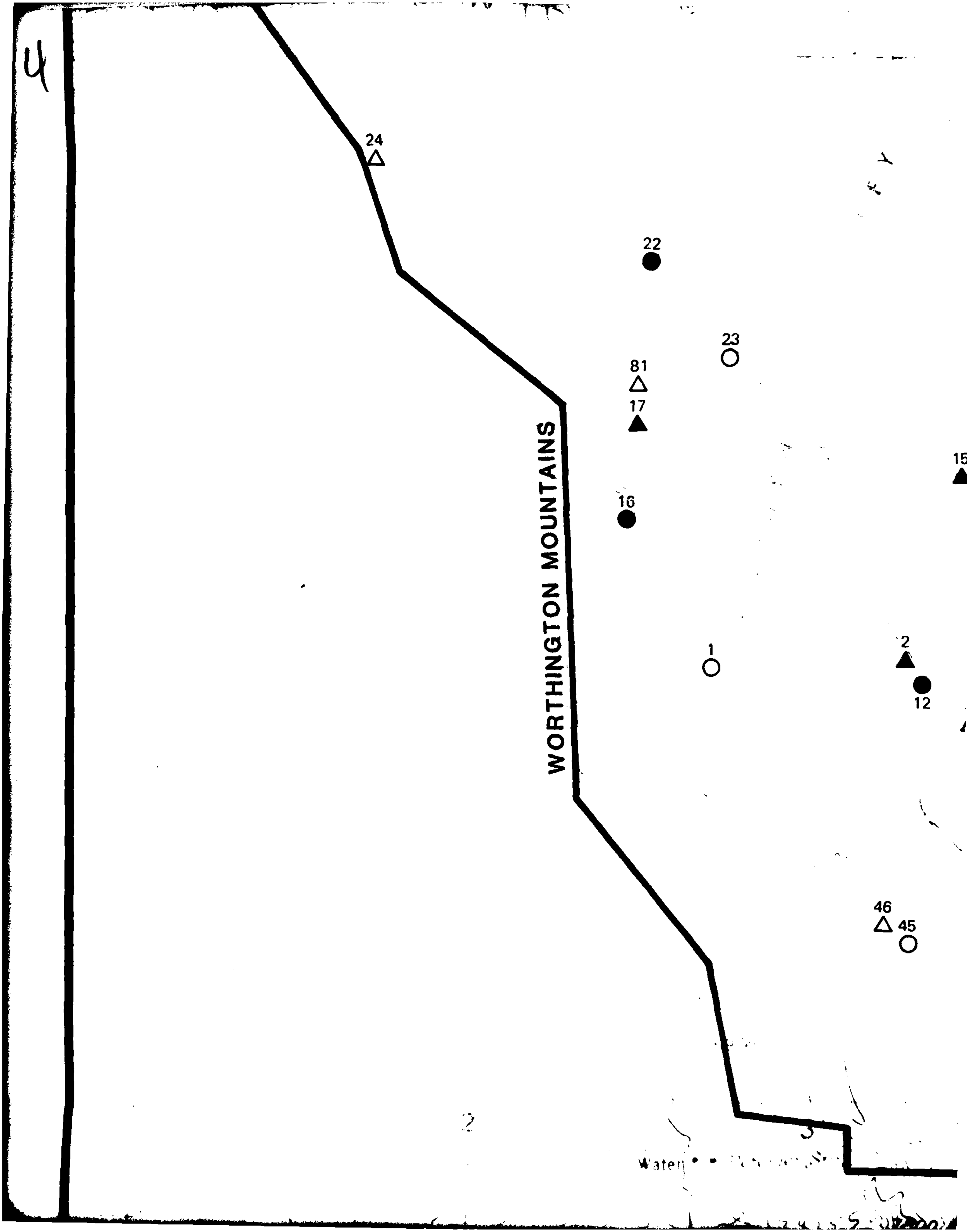

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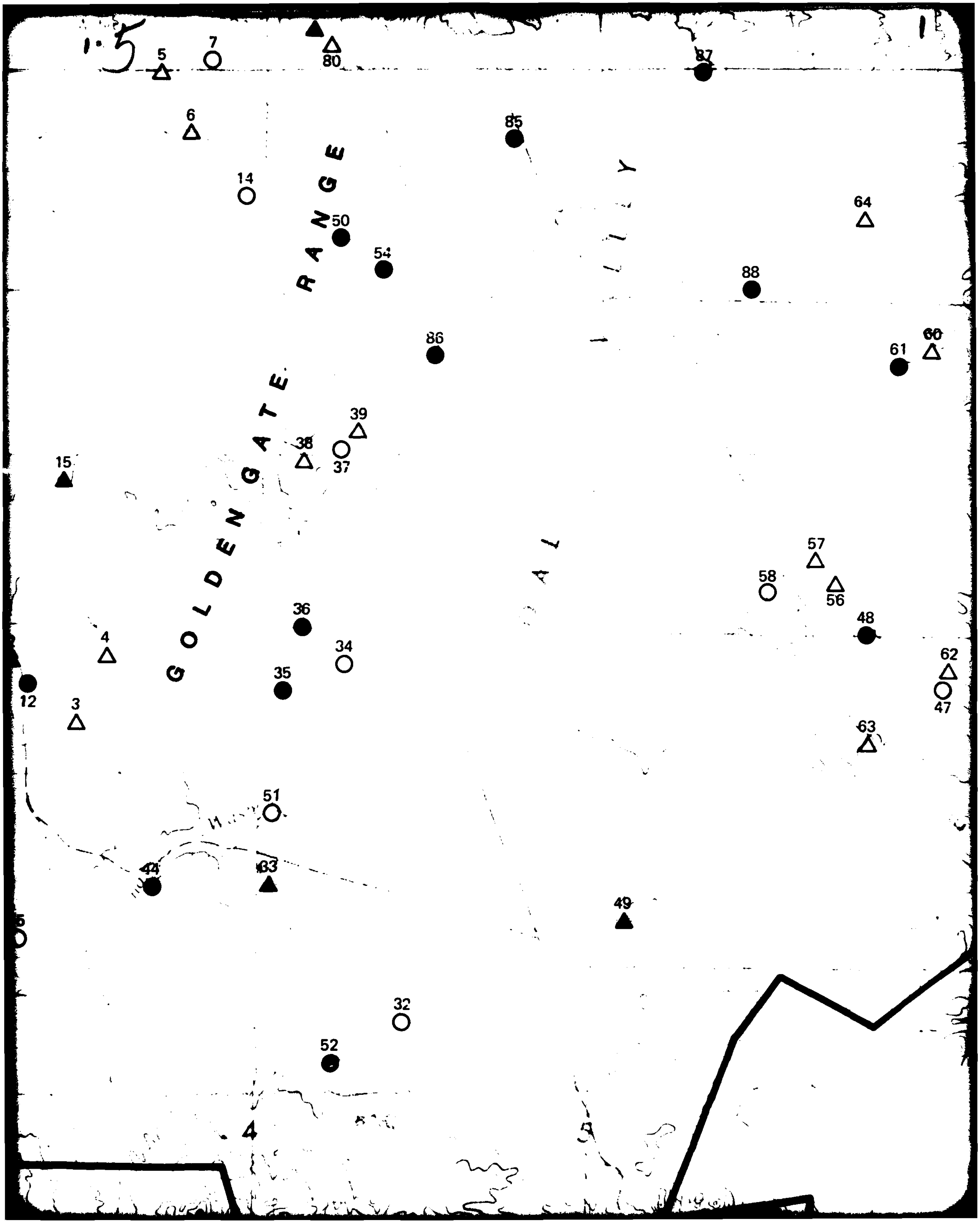
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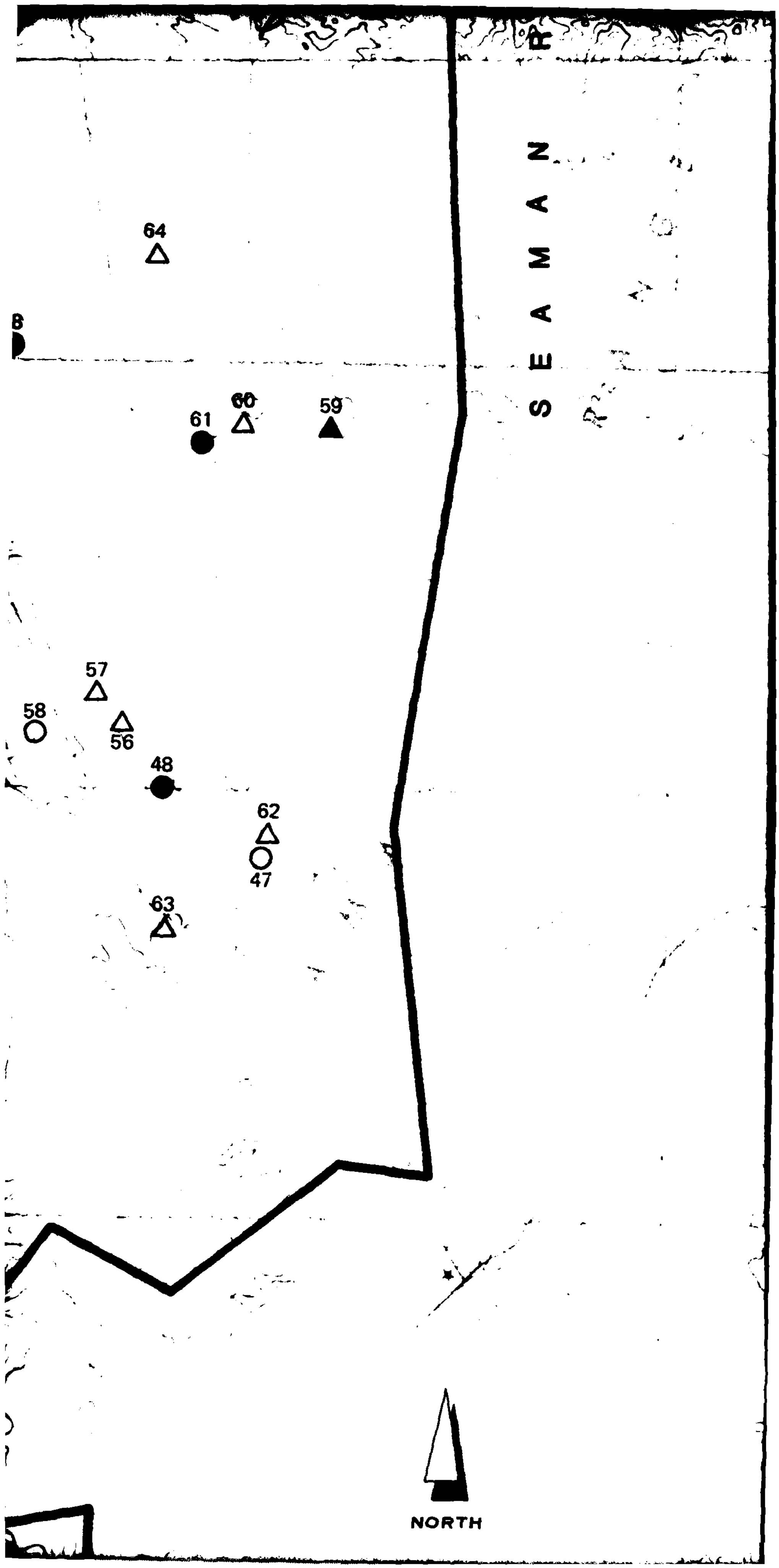

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NORTH

EXPLANATION

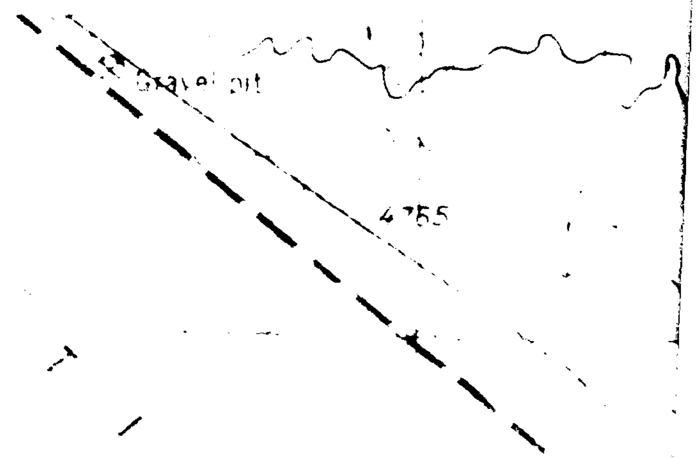
ERTEC WESTERN FIELD STATIONS

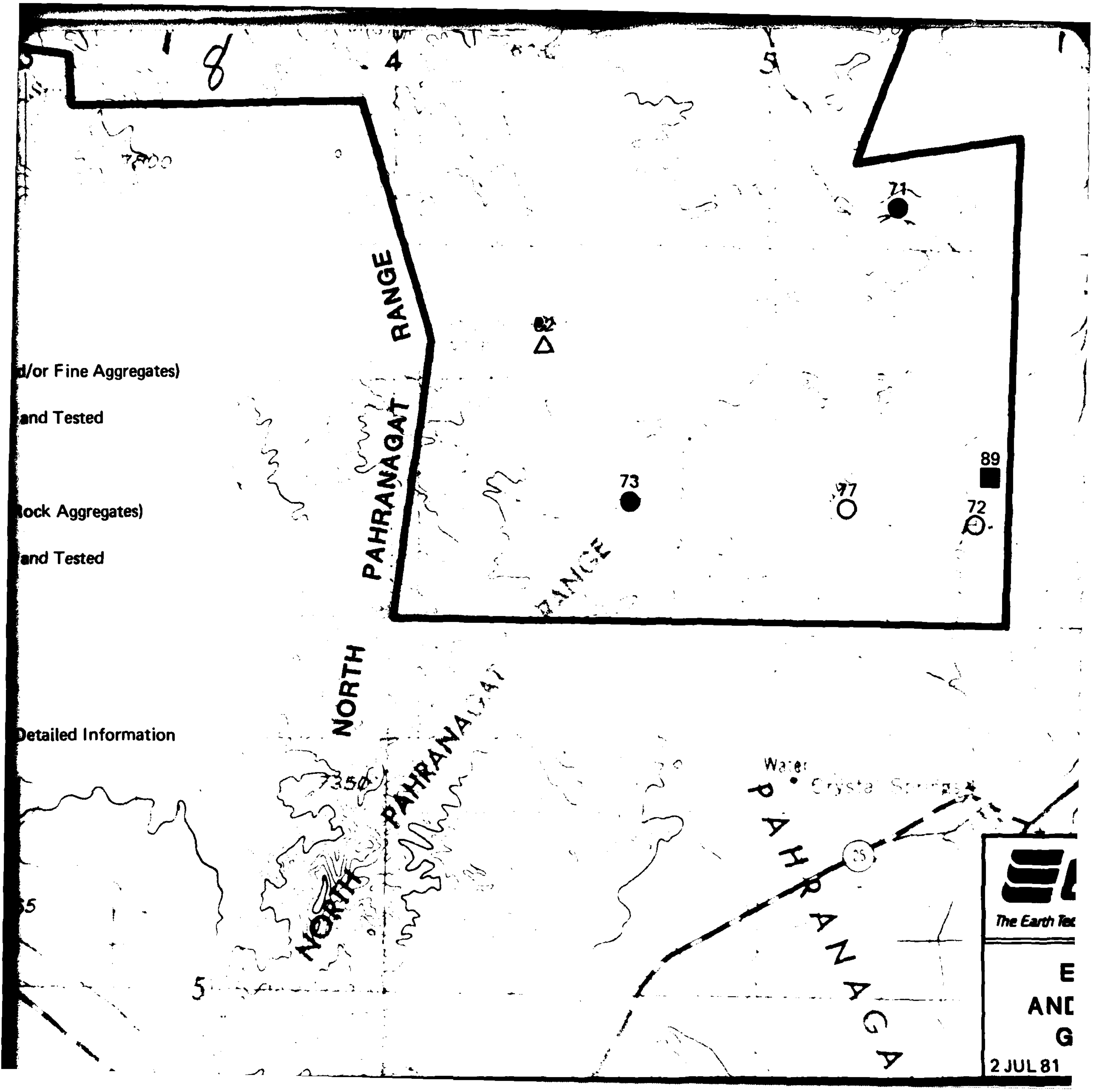
BASIN–FILL UNITS	(Potential Coarse and/or Fine Aggregates)
●	Data Stop, Sampled and Tested
○	Data Stop
ROCK UNITS	(Potential Crushed Rock Aggregates)
▲	Data Stop, Sampled and Tested
△	Data Stop

EXISTING TEST DATA SITES

■	Test Data Available

Note: See Corresponding Map Number in Appendix A for Detailed Information





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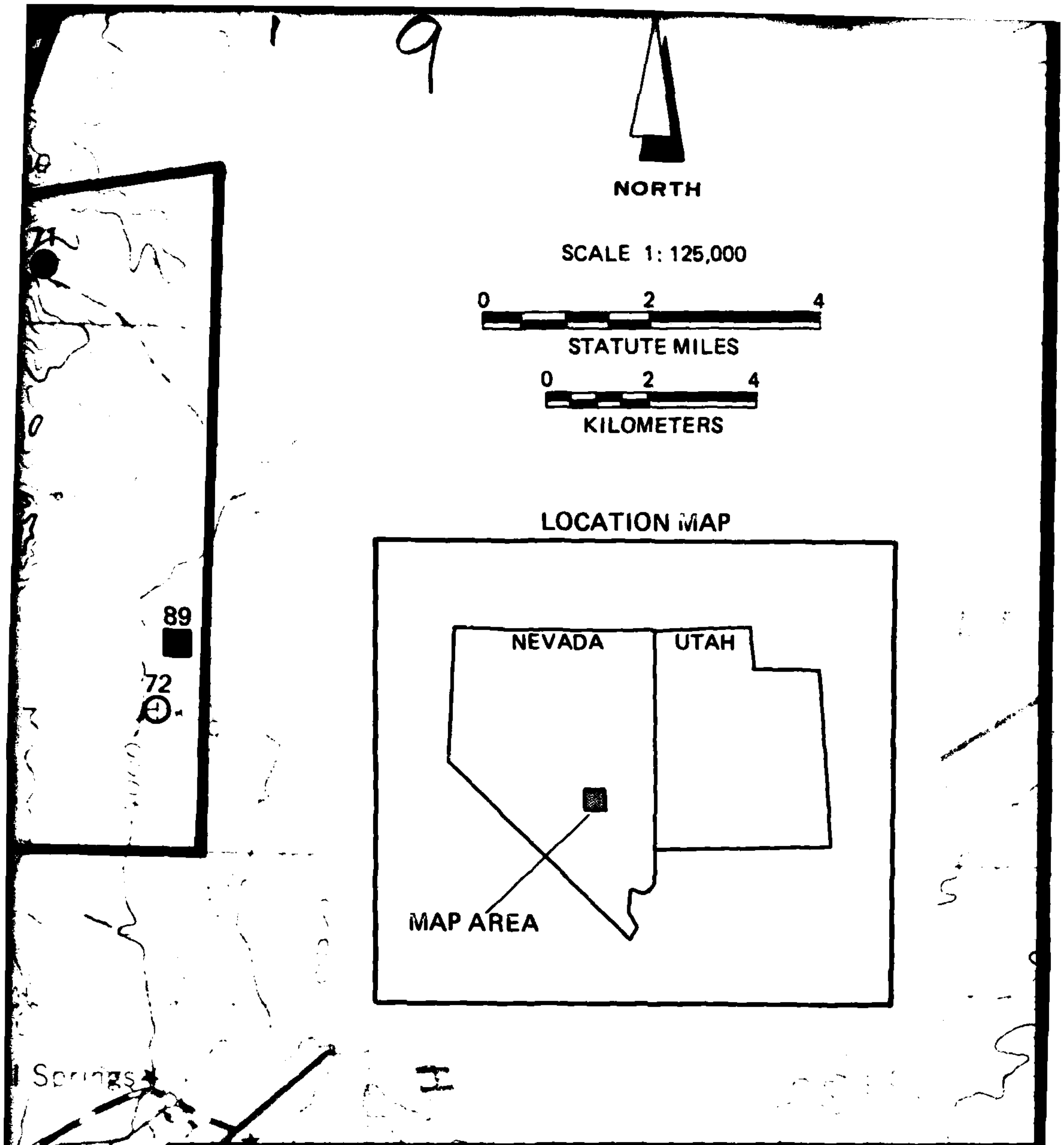

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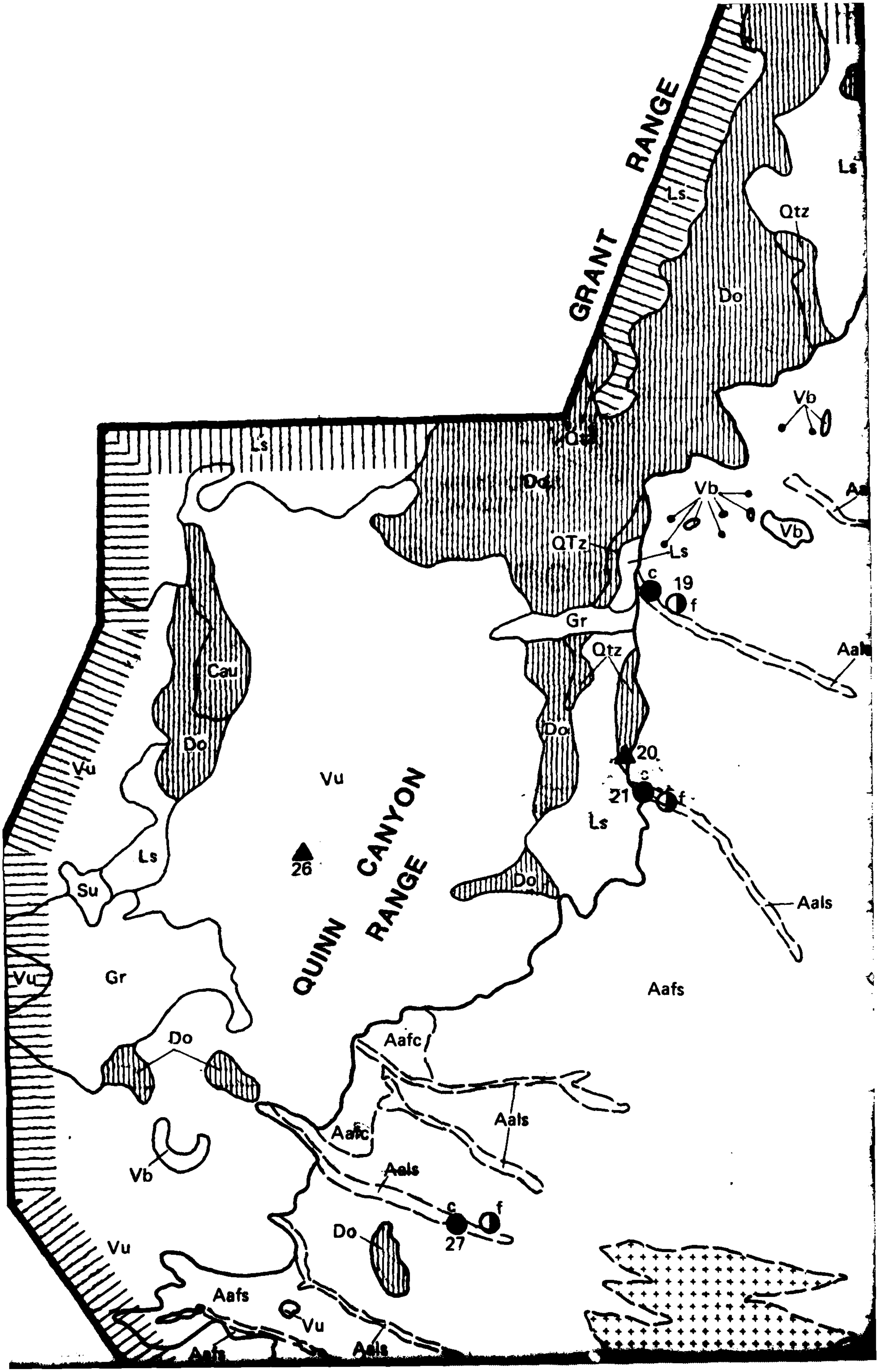
ERTEC WESTERN FIELD STATION AND EXISTING DATA SITE LOCATIONS GARDEN-COAL VALLEYS, NEVADA

2 JUL 81

DRAWING 1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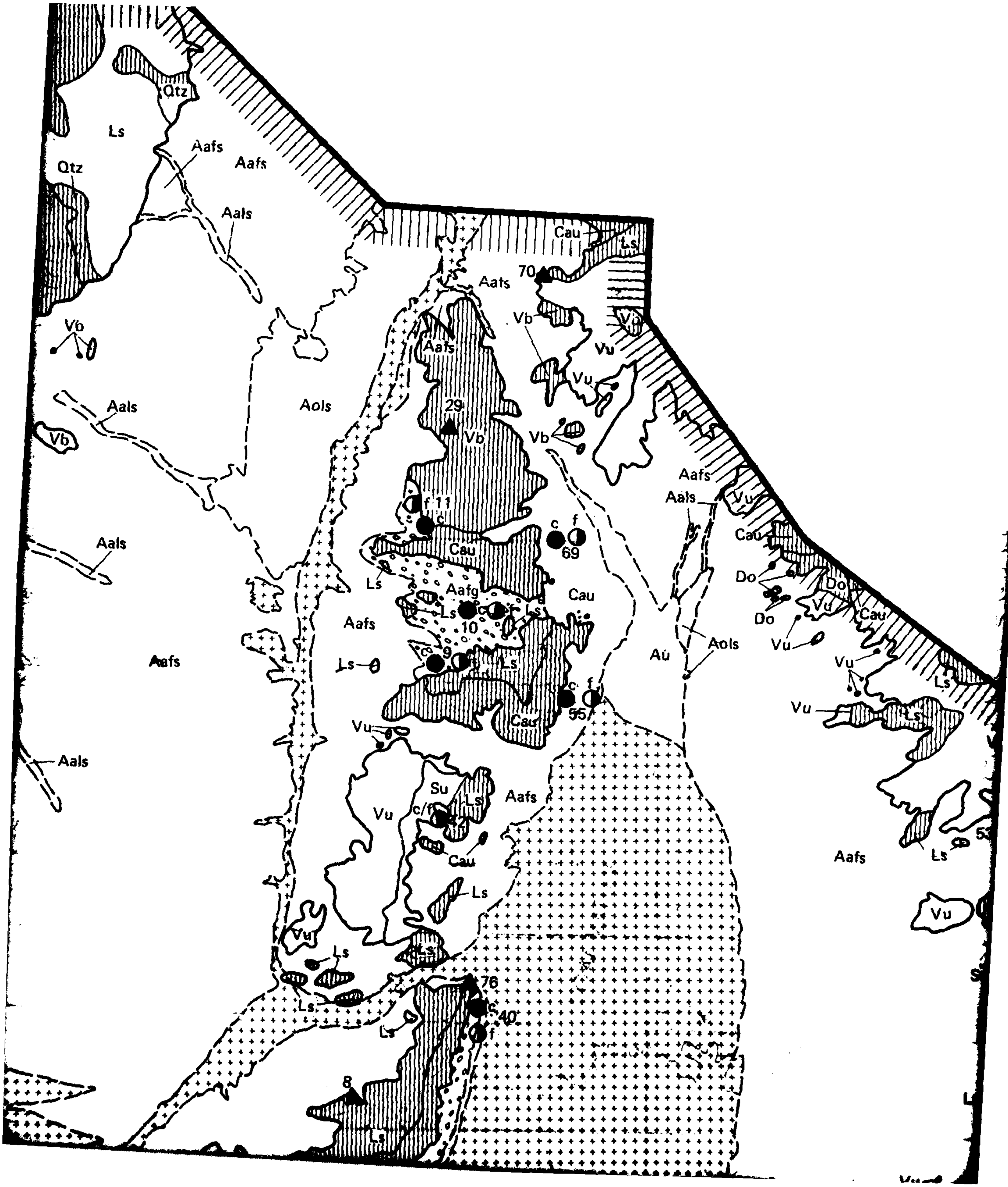

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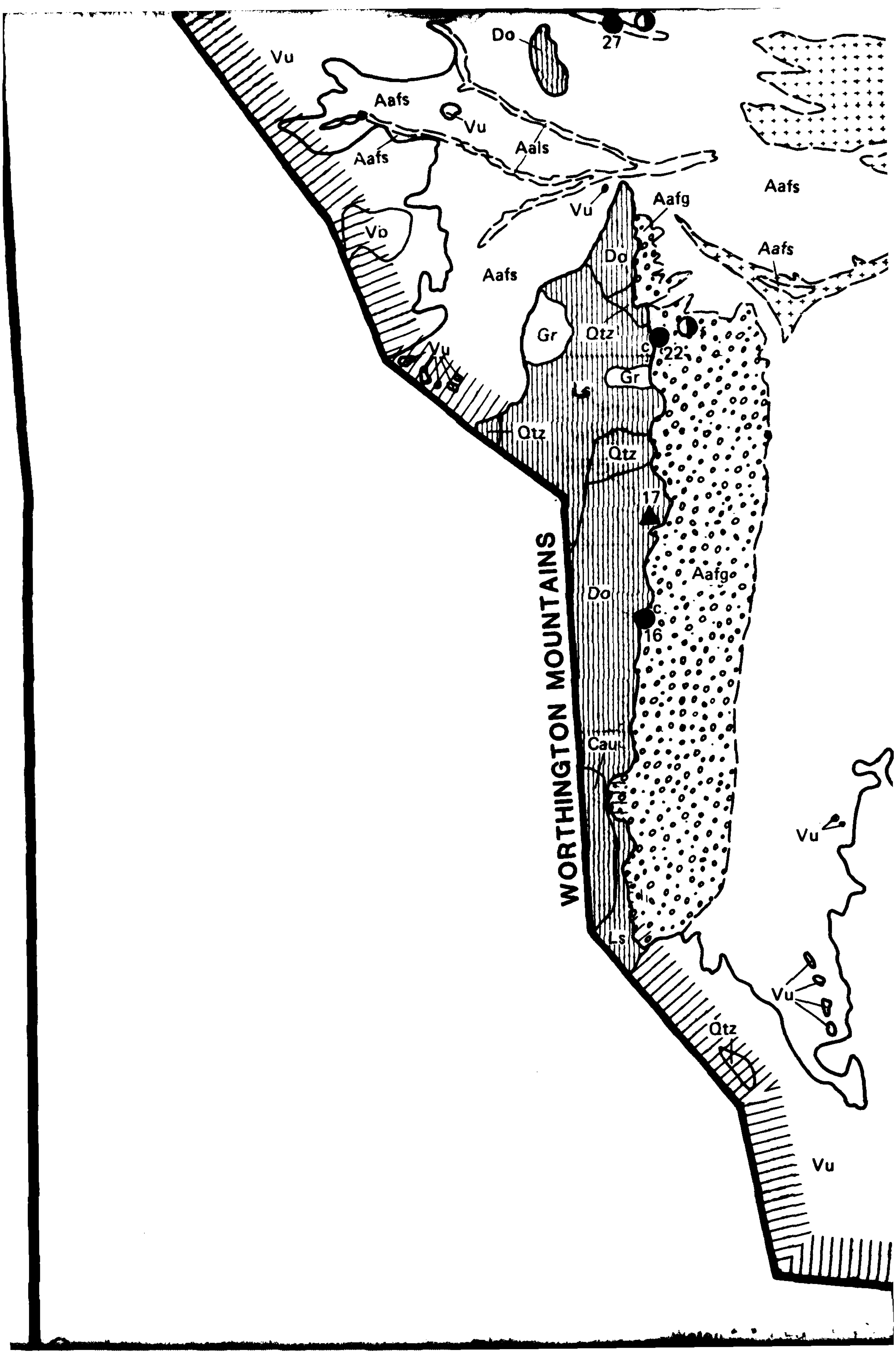

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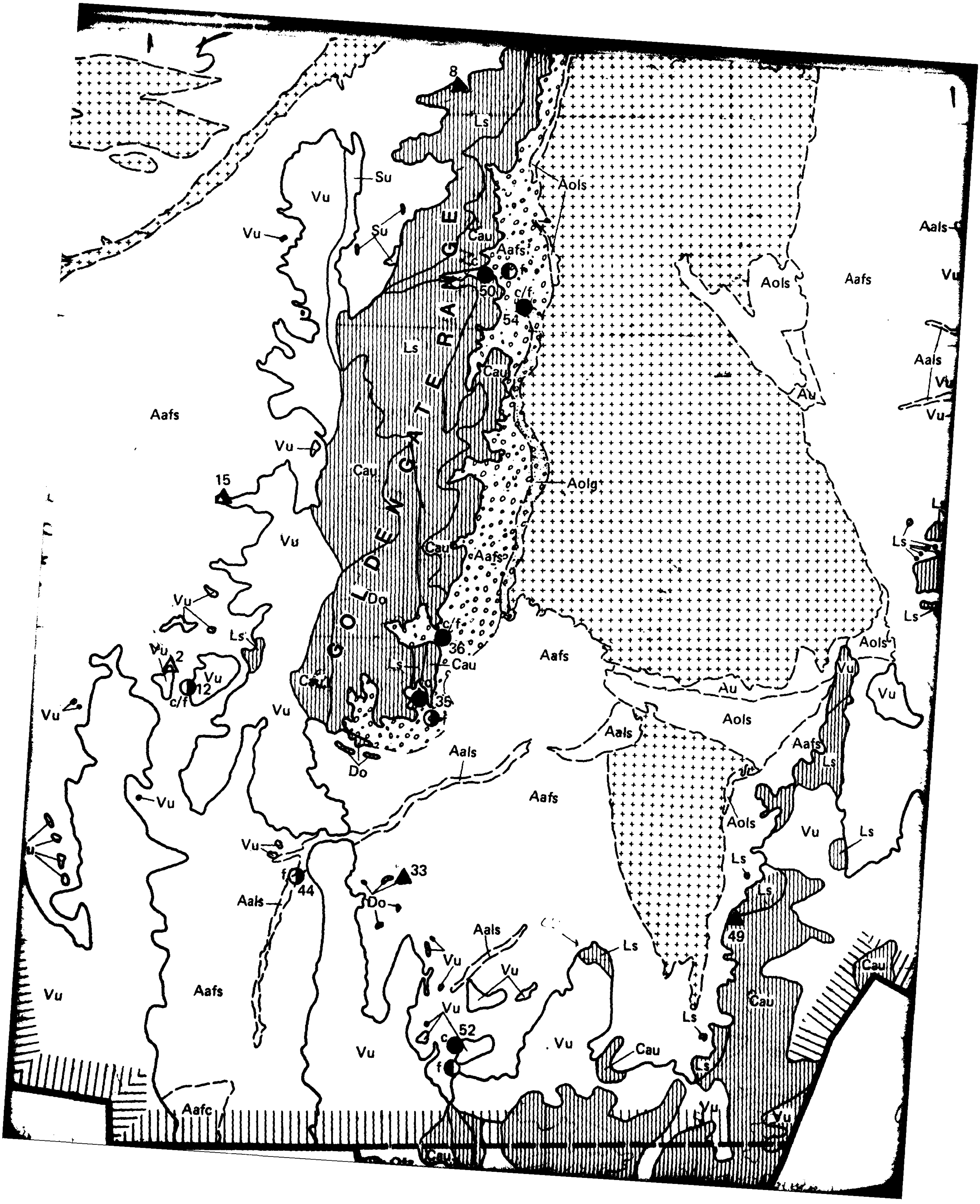
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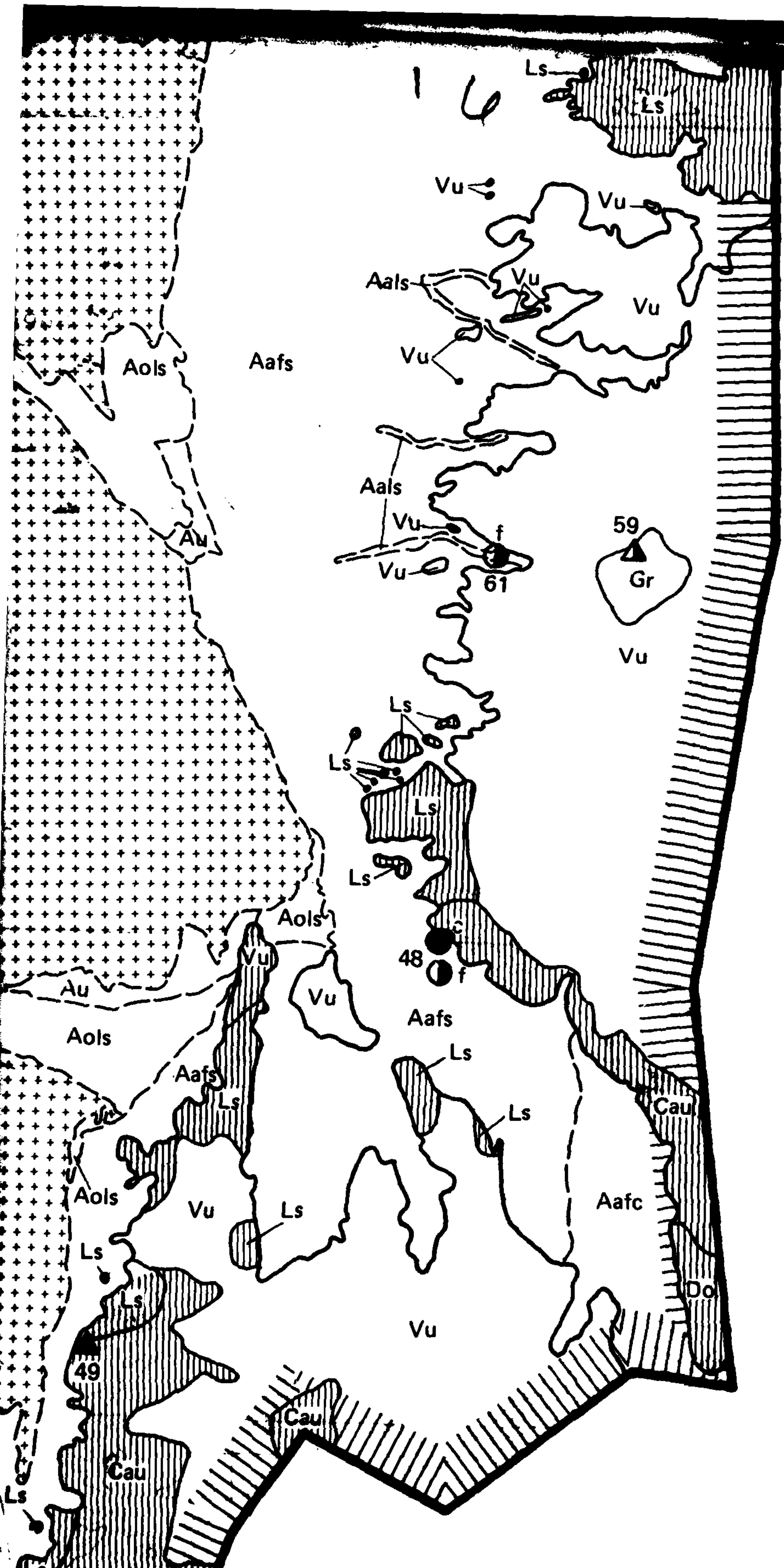
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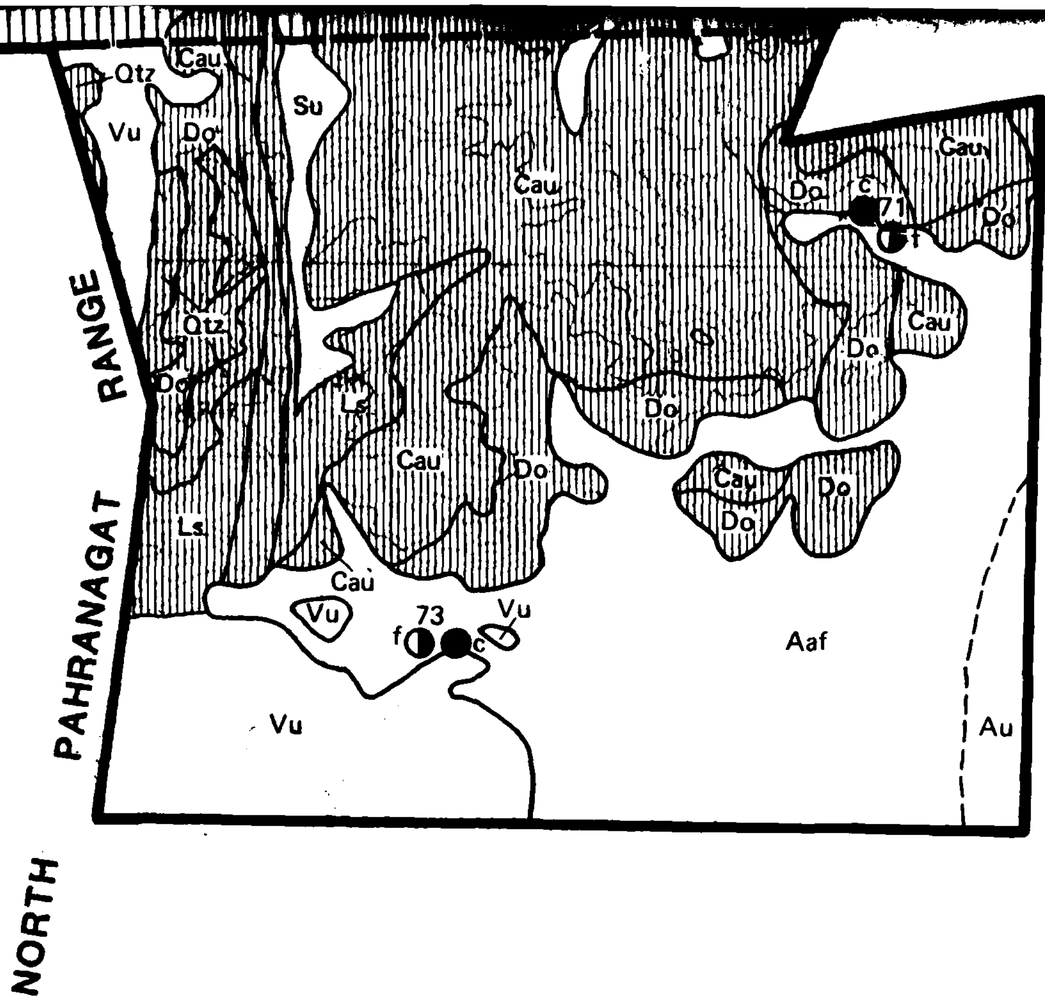
EXPLANATION

POTENTIAL AGGREGATE SOURCES

BASIN–FILL UNITS *

Aal	Stream Channel and Terrace Deposits	(A1)
Aaf	Alluvial Fan Deposits	(A5)
Aol	Older Lacustrine Deposits	(A4o)
Au	Alluvial Deposits Undifferentiated	
Vb	Basalt	(I 3)
Vu	Volcanic Rocks Undifferentiated	(I 2 and/or I 4)

1 8



CLASSIFICATION SYSTEM

BASIN–FILL SOURCES

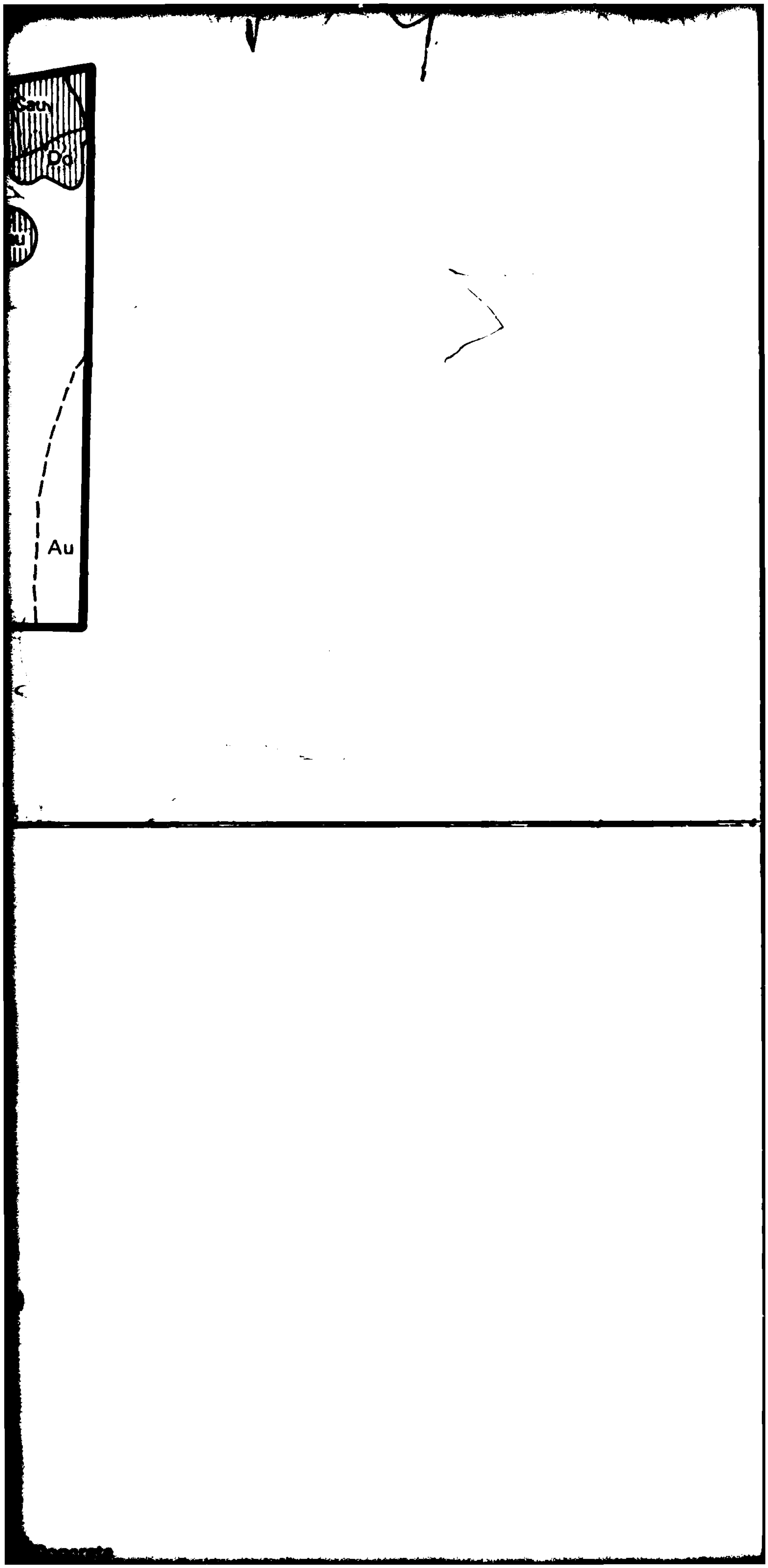
Class I – Potentially Suitable Coarse, Concrete Aggregate or Road - Base Material Source

Class I – Potentially Suitable Coarse and Fine (Multiple Source) Concrete Aggregate or Road-Base Material Source

ROCK SOURCES

Class I – Potentially Suitable Crushed Rock, Concrete Aggregate or Road-Base Material Source

BASIN–FILL AND ROCK SOURCES


Au

10

Vb	Basalt	(I 3)
Vu	Volcanic Rocks Undifferentiated	(I 2 and/or I 4)
Gr	Granitic Rock	(I 1)
Qtz	Quartzite	(M4 and/or S1)
Ls	Limestone	(S2)
Do	Dolomite	(S2)
Cau	Carbonate Rocks Undifferentiate	(S2)
Su	Sedimentary Rocks Undifferentiated	(S)

* Reference Appendix E for Symbol Explanation and Comparison

Aafg	Material type (Aaf) and Grain Size Designation (g). Grain size designations are coarse (c), gravel (g) and sand (s).
—— – –	Geologic Contact, Dashed Where Approximate
– – – –	Approximate Concrete Aggregate and/or Road-Base Materials Source Boundary
	Verification Study Area

SAMPLED AND TESTED FIELD STATIONS

BASIN–FILL AGGREGATE SAMPLE COARSE (c) AND FINE (f)	CRUSHED ROCK SAMPLE	CLASSIFICATION
●	▲	CLASS I
◑	◭	CLASS II
○	△	CLASS III

NOTE: SEE CORRESPONDING MAP NUMBER IN APPENDIX A FOR DETAILED INFORMATION

BASIN–FILL AND ROCK SOURCES

Class II – Possibly Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate/Potentially Suitable Road-Base Material Source

Class III – Unsuitable Coarse, F ine and/or Crushed Rock Concrete Aggregate or Road-Base Material Source

NORTH

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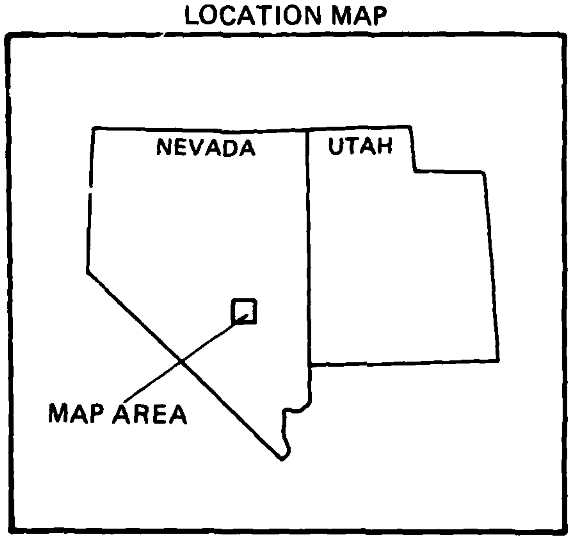
LOCATION MAP



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AGGREGATE RESOURCES MAP
GARDEN–COAL VALLEYS, NEVADA

2 JUL 81

DRAWING 2

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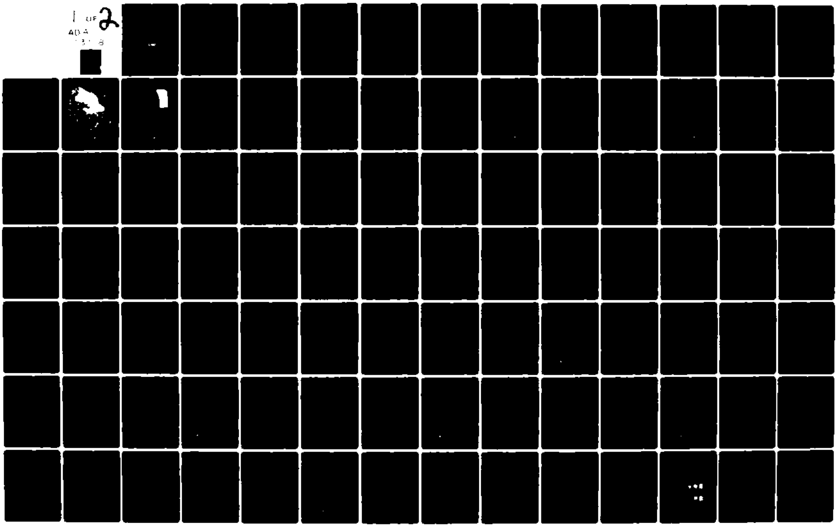

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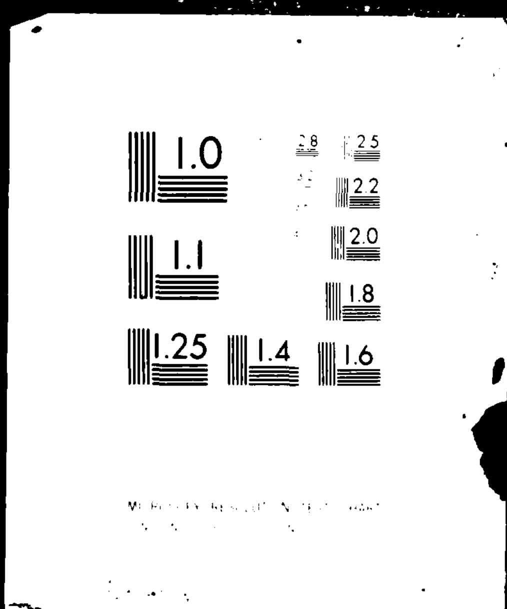

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AGGREGATE RESOURCES STUDY

GARDEN AND COAL VALLEYS

NEVADA

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

Prepared by:

Ertec Western, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

2 July 1981

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Aggregate Resources Study Garden + Coal Valleys, Nevada	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER: E-TR-37-i
7. AUTHOR(s): Ertec Western, Inc.	8. CONTRACT OR GRANT NUMBER(s): F04704-80-C-0006
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ertec Western Inc. (formerly Fugro National) P.O. Box 7765 Long Beach CA 90807	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64312 F
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Department of the Air Force Space and Missile Systems Organization Norton AFB CA 92409 (SAMSO)	12. REPORT DATE: 2 Jul 81
	13. NUMBER OF PAGES: 47
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Geology, ~~Setting~~, ~~Potential~~ Aggregate ~~Sources~~, grain size, trench logs, sieve analysis, alluvium, basin fill

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the Valley-Specific Aggregate Resources Study (VSARS) evaluation for Garden and Coal valleys and surrounding areas in Nevada. It is the ninth in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and rock sources for concrete and road-base construction materials. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Nevada Department of Highways, previous regional aggregate investigations and ongoing Verification studies.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A2. It presents the results of Valley-Specific Aggregate Resources Studies within and adacent to selected lands in Utah and Nevada that are under consideration for siting the MX system.

This volume contains the results of the Aggregate Resources study in Garden and Coal valleys. It is the ninth of several Valley Specific Aggregate Resources investigations which will be prepared as separate volumes. Results of this report are presented as text, appendices, and two drawings.

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EXECUTIVE SUMMARY

This report contains the Valley-Specific Aggregate Resources Study (VSARS) evaluation for Garden and Coal valleys and surrounding areas in Nevada. It is the ninth in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Nevada Department of Highways, previous regional aggregate investigations, and ongoing Verification studies.

A classification system based on aggregate type and potential use was developed to rank the suitability of all basin-fill and rock aggregate sources. Four aggregate types have been designated; coarse, fine, coarse and fine (multiple) aggregates derived from basin-fill sources, and crushed rock aggregates derived from rock sources. Each aggregate type was then classified using the following definitions:

Class I — Potentially suitable concrete aggregate or road-base material source;

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source; and

Class III — Unsuitable concrete aggregate or road-base material source.

Decisions on assigning a particular aggregate source to one of the three classes were determined from existing test data and

Ertec Western, Inc. (formerly Fugro National, Inc.) laboratory aggregate tests performed as part of this study (abrasion resistance, soundness, and alkali reactivity) and, to a lesser degree, field visual observations.

Emphasis in this study was placed on the identification of Class I basin-fill coarse aggregate. These deposits are considered to be the primary sources of concrete and road-base construction materials. Results of the study are presented in a 1:125,000 scale aggregate resources map (Drawing 2) and are summarized as follows:

1. Coarse Aggregate - Major Class I coarse aggregate deposits are located in the Garden and Coal valley study area in:

    a. Alluvial fan (Aafs) and older lacustrine (Aolg) deposits in southwestern Coal Valley;

    b. Alluvial fan deposits (Aafg) in southwestern Garden Valley; and

    c. Alluvial fan deposits (Aafg) in northeastern Garden Valley.

    Potentially suitable Class II coarse aggregate sources are widespread in the study area. They are typically located within alluvial fan (Aafs, Aaf, Aafc) and older lacustrine (Aols) deposits flanking Class I and/or Class II rock sources.

2. Fine Aggregate - Class I fine aggregate (multiple-type) sources were delineated in:

    a. Older lacustrine deposits (Aolg) in southwestern Coal Valley; and

b. Alluvial fan deposits (Aafs) in southwestern Coal Valley.

Potential Class II fine aggregate sources typically occurring basinward of most Class I and Class II rock exposures are extensively distributed throughout the study area.

Many coarse aggregate basin-fill sources are also potential multiple sources (coarse and fine) that will supply varying quantities of fine aggregate either from the natural deposit or during processing.

3. Crushed Rock - Abundant Class I crushed rock sources are present throughout the study area in:

   a. Guilmette Formation and undivided Ordovician through Mississippian rocks (Cau) in the Worthington Mountains and Golden Gate, Seaman, and North Pahranagat ranges;

   b. Laketown, Sevy, and Simonson dolomites (Do) in the Worthington Mountains and Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges;

   c. Joana and Ely limestones (Ls) in the Worthington Mountains and Golden Gate, Seaman, and North Pahranagat ranges;

   d. Eureka Quartzite (Qtz) in the Worthington Mountains and Quinn Canyon, Grant, and North Pahranagat ranges; and

   e. Basalt (Vb) in the northern Golden Gate Range.

The usability of any of these rock units as sources of crushed rock aggregate depends on their accessibility and minability within the study area.

Additional aggregate testing and field investigations will be required to further refine the lateral and vertical extents of classification boundaries and define exact physical and chemical

characteristics of a particular deposit or rock source within the study area.

1.0 INTRODUCTION

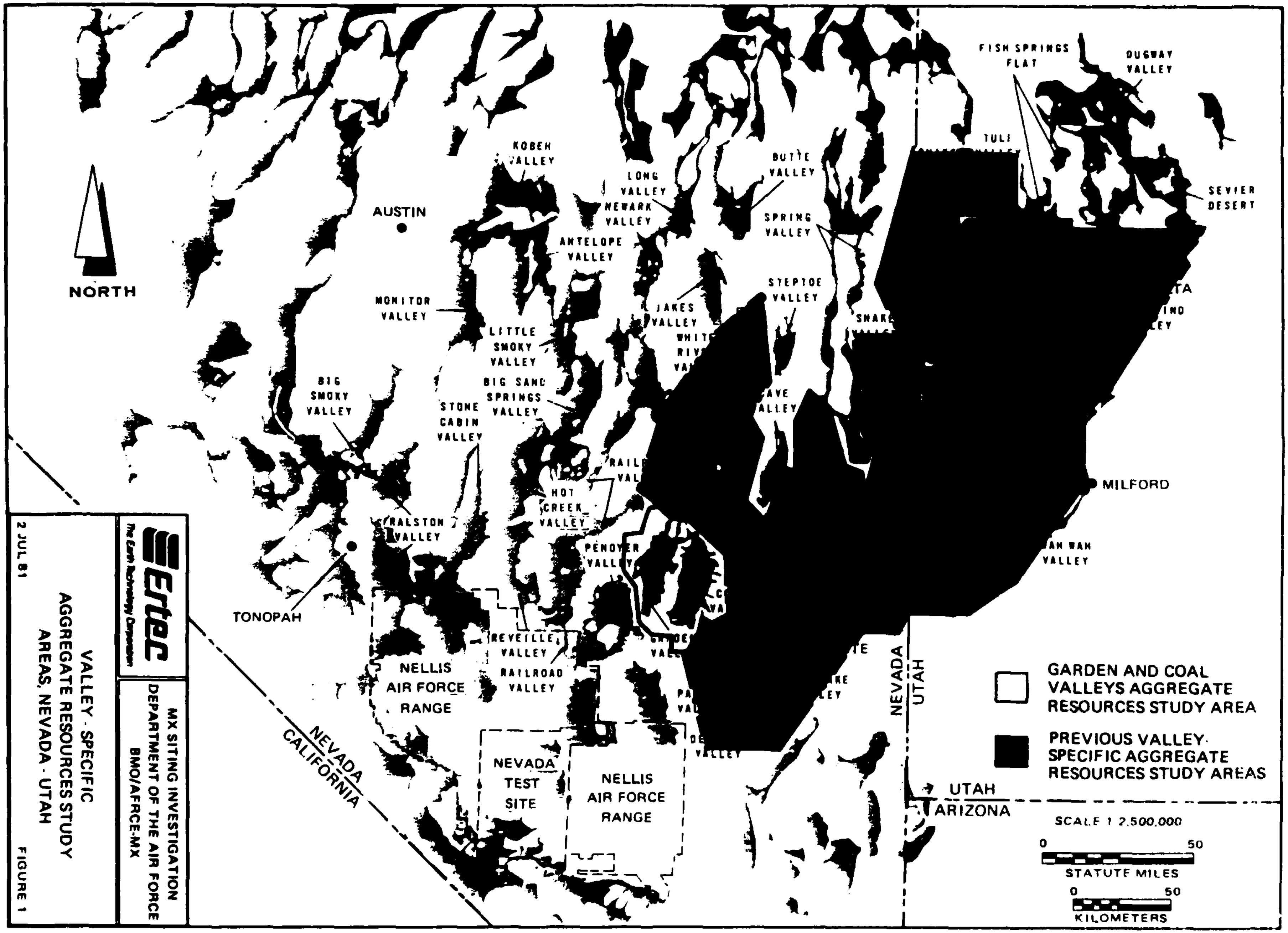
1.1 STUDY AREA

This report presents the results of the Valley-Specific Aggregate Resources Study (VSARS) completed for Garden and Coal valleys (Figure 1). The study area is located in portions of Lincoln and Nye counties, Nevada. Garden and Coal valleys are north-south trending alluvial basins bounded by mountain ranges of sedimentary and/or igneous rocks. These are the Worthington Mountains and the Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges. Adjoining basins are Spring, Railroad, White River, Pahroc, Pahranagat, and Tikaboo valleys. No paved road access is provided but graded roads and four-wheel-drive trails are present throughout the study area.

The study area is comprised mainly of desert rangeland managed by the Bureau of Land Management (BLM). The northwestern part of the area is part of the Humboldt National Forest. Isolated private land and localized mining claims are also present.

1.2 BACKGROUND

The MX aggregate program began in 1977 with the investigation of Department of Defense (DoD) and BLM lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not studied in the initial Aggregate Resources Evaluation Investigation (AREI). This additional area (Figure 2), defined as the Utah Aggregate Resources Study Area (UARSA), was evaluated in the fall 1979, and a second general aggregate resources report



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VALLEY - SPECIFIC
AGGREGATE RESOURCES STUDY
AREAS, NEVADA - UTAH

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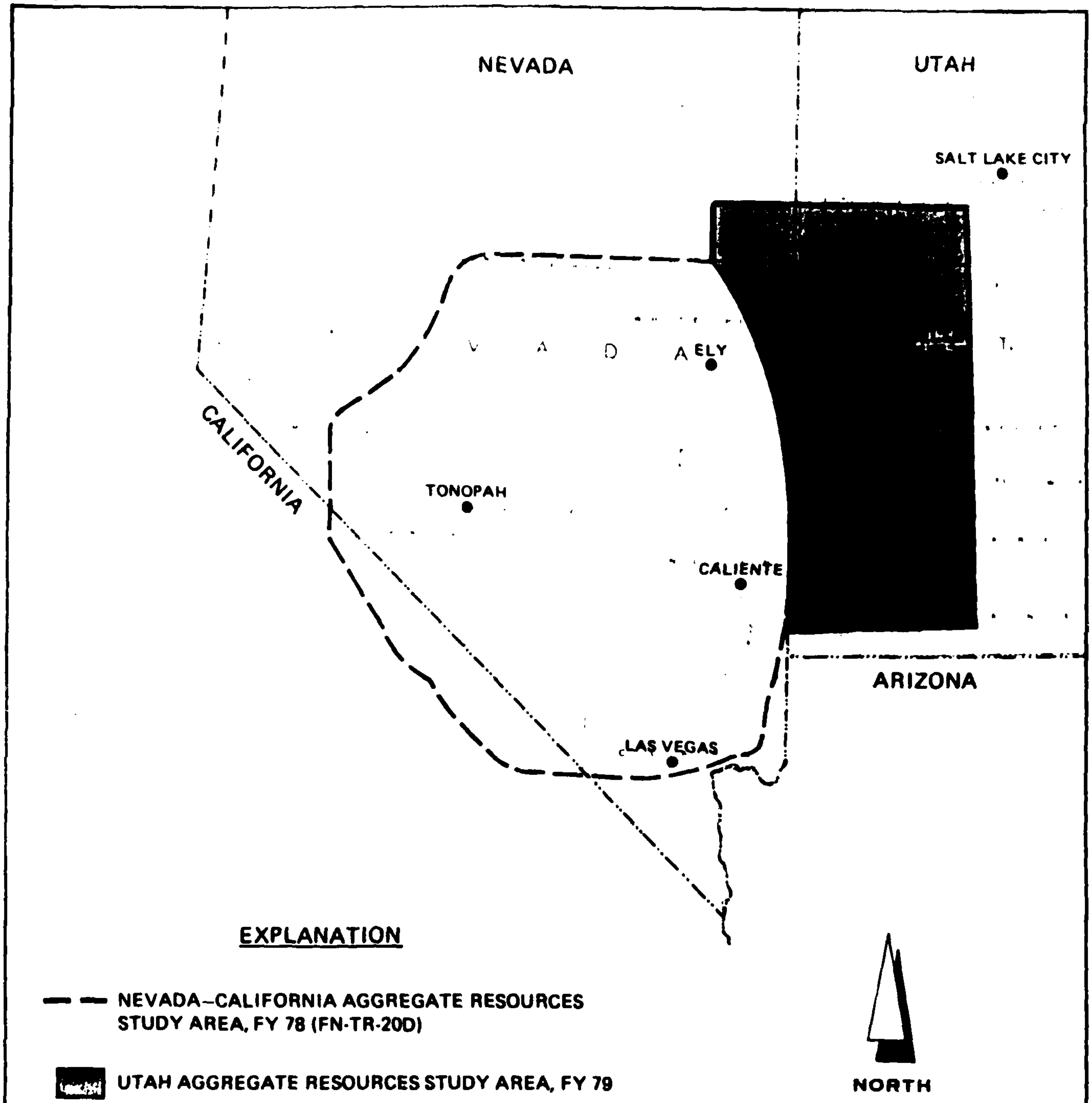
FIGURE 1



EXPLANATION

NEVADA–CALIFORNIA AGGREGATE RESOURCES STUDY AREA, FY 78 (FN-TR-20D)

UTAH AGGREGATE RESOURCES STUDY AREA, FY 79

SCALE 1: 5,000,000

0 50 100
STATUTE MILES

0 50 100
KILOMETERS

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UTAH–NEVADA REGIONAL
AGGREGATE STUDIES

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FIGURE 2

(FN-TR-34) was submitted on 3 March 1980. Both general aggregate investigations were designed to provide regional information on the location, quality, and quantity of aggregates that could be used in the construction of the MX system.

Subsequent to the general studies, VSARS were developed in FY 79 to provide more-detailed information on potential aggregate sources in specified valley areas.

1.3 OBJECTIVES

The primary objective of the VSARS program is to classify, on a valley basis, basin-fill deposits and rock units for suitability as concrete and road-base construction materials. The format is designed to select and present the locations of the most acceptable aggregate sources for preliminary construction planning and follow-on detailed aggregate investigations.

1.4 SCOPE

The scope of this investigation required office and field studies and included the following:

1. Collection and analyses of available existing data on the quality and quantity of potential concrete aggregate and road-base material sources. American Society of Testing and Materials (ASTM) standards and Standard Specifications for Public Works Construction (SSPWC) were used to evaluate quality;

2. Aerial and ground reconnaissance of all identified potential aggregate sources in the valley area, with more-detailed investigation and sample collection of likely basin-fill (coarse and fine aggregates) and rock (crushed rock aggregates) construction material sources;

3. Laboratory testing to supplement available existing data and to provide detailed information to assist in determining the

suitability of specific basin-fill or rock as construction material sources within the study area; and

4. Development and application of an aggregate classification system (Section 2.5) that emphasizes aggregate type (coarse, fine, or crushed rock) and potential construction use (concrete and/or road base).

2.0 STUDY APPROACH

2.1 EXISTING DATA

Collection of existing test data from available sources was an important factor in the VSARS program. The principal source of existing data pertaining to aggregate construction materials was the Nevada Department of Highways (Appendix A). The majority of this information is related to the use of aggregate material for asphaltic concrete, base course in road construction, or ballast material; however, many of the suitability tests for these types of construction materials are similar to those for concrete and are applicable to this investigation.

2.2 SUPPLEMENTAL ERTEC DATA

Supplemental Ertec data were obtained from: 1) field data and supplementary test data collected during the general aggregate resources studies (FN-TR-20D), 2) Garden and Coal Valley Verification studies (FN-TR-27), and 3) the current (Appendix A) and previous (FN-TR-37) Valley Specific Aggregate Resources Studies.

The primary objective of the initial aggregate study was a regional evaluation and ranking of all potential aggregate sources. Five data points from the general aggregate studies were located within the VSARS area (Drawing 1).

Verification geologic maps are an initial source of information on the type and extent of basin-fill units within specific valley areas. While the Verification studies are not specifically

designed to generate aggregate information, some of the data collected are applicable to the aggregate evaluation. Data from six verification trenches were used in the evaluation of grain-size gradations in the study area (Appendix A). Depths of the selected trenches ranged from 4 to 10 feet (1.2 to 3.0 m).

The VSARS program required aerial and ground reconnaissance of the study area to collect additional information to verify conditions determined during the data review. Included in the 77 field station data stops was the collection of 37 samples for additional laboratory testing. Potential coarse- and fine-aggregate basin-fill samples were collected by sampling stream cuts or existing man-made exposures. Potential crushed-rock aggregate samples were obtained from exposures of fresh or slightly weathered material whenever possible. The weight of the samples collected ranged between 100 and 150 pounds. Hand samples were collected from rock units for office analyses.

Identification of basin-fill materials in all field studies followed ASTM D 2488-69, Description of Soils (Visual-Manual Procedure), and the Unified Soil Classification System (Appendix C). Rock identifications followed procedures described in the Quarterly of the Colorado School of Mines (Travis, 1955) and Standard Investigative Nomenclature of Constituents of Natural Mineral Aggregates (ASTM C 294-69).

2.3 DATA ANALYSIS

Geologic and engineering criteria were used in the evaluation of potential aggregate sources within the study area. This was

supplemented by laboratory analysis of selected samples during the valley-specific aggregate testing program (Table 1). Coarse aggregate is defined as predominantly plus 0.185 inch (4.75 mm) fine gravel to boulder basin-fill material. Fine aggregate is defined as less than 0.375 inch (9.5 mm) and predominantly less than 0.185 inch (4.75 mm), but greater than 0.0029 inch (0.074 mm), coarse to fine sand basin-fill material. While all laboratory tests supplied definitive information, the abrasion, soundness, and alkali reactivity results were considered the most critical in determining the use and acceptablity of a potential aggregate source.

2.4 PRESENTATION OF RESULTS

Results of the study are presented in text, tables, appendices, and two 1:125,000 scale maps. Drawing 1 presents the location of the 89 Ertec and existing data sites within the study area. Drawing 2 presents the location of all VSARS laboratory sample sites and all potential basin-fill and rock aggregate sources within the study area. In addition, these potential aggregate sources are classified according to proposed aggregate use and type (Section 2.5).

Geologic unit symbols utilized in Drawing 2 relate to standard geological nomenclature whenever possible. Undifferentiated basin-fill deposits and rock units were established primarily to accommodate accuracy of data and map scale and may contain deposits which could supply significant quantities of high-quality materials. A conversion table to relate these geologic symbols

ASTM TEST	SAMPLE TYPE AND NUMBER OF TESTS		
	COARSE	FINE	ROCK
ASTM C-88; SOUNDNESS BY USE OF MAGNESIUM SULFATE	23	24	11
ASTM C-131; RESISTANCE TO ABRASION BY USE OF THE LOS ANGELES MACHINE	23	NA	12
ASTM C-136; SIEVE ANALYSIS	25	25	NA
ASTM C-289; POTENTIAL REACTIVITY OF AGGREGATE (CHEMICAL METHOD)	10	8	4
ASTM C-127 AND C-128; SPECIFIC GRAVITY AND ABSORPTION	9	5	4

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AGGREGATE RESOURCES STUDY
AGGREGATE TESTS
GARDEN AND COAL VALLEYS, NEVADA

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TABLE 1

to the geologic unit nomenclature used in Ertec Verification studies is contained in Appendix E.

All contacts which represent distinct boundaries between geologic units are shown as solid lines in Drawing 2. The contacts are dashed where the data were extrapolated beyond the limits of the source data or where accuracy of the data may be questionable. Local small deposits of one geologic unit may be found in close association with a larger deposit of a different geologic unit. Due to the reconnaissance level of the field investigation or map-scale limitations, these smaller deposits could not be depicted on the aggregate resources map and have been combined with the more prevalent material. Similarly, potential aggregate source classifications are preliminary and may contain lesser amounts of material of another use or type. Therefore, all classification lines are dashed and delimit the best aggregate evaluations possible at this level of investigation. In cases of highly variable rock or basin-fill units and limited aggregate tests, boundaries could not be drawn and individual sample information is presented in Drawing 2.

Appendices contain tables summarizing the basic data collected during Ertec's supplemental field investigations, the results of Ertec's supplemental testing programs, and existing test data gathered from various outside sources (Appendix A). Also included in appendices are an explanation of caliche development (Appendix B), the Unified Soil Classification System (Appendix C), photographs of typical aggregate sources within the Garden

and Coal valleys study area (Appendix D), and a geologic unit cross-reference table (Appendix E).

2.5 PRELIMINARY CLASSIFICATION OF POTENTIAL AGGREGATE SOURCES

A system was developed to preliminarily classify all potential aggregate sources in the study area. This classification is designed to present the best potential sources of coarse, fine, coarse and fine (multiple source), and crushed-rock aggregate types within a valley-specific area (Drawing 2) based on potential aggregate use (Table 2). Concrete aggregate parameters are the principal consideration in this report as materials suitable for use as concrete aggregates are generally acceptable for use as road-base material. Therefore, the three classifications described below are based primarily on results of the abrasion, soundness, and alkali reactivity tests.

Class I — Potentially suitable concrete aggregate or road-base material sources. Coarse and crushed-rock aggregates which either passed abrasion, soundness, and alkali reactivity tests or passed abrasion and soundness tests and were not tested for alkali reactivity; fine aggregates which either passed soundness and alkali reactivity tests or passed soundness tests and were not tested for alkali reactivity.

Class II — Possibly unsuitable concrete aggregate/ potentially suitable road-base material source. Coarse, fine, and crushed-rock aggregates which either failed the soundness and/or alkali reactivity tests or were classified only by field visual observations or other test data.

Class III — Unsuitable concrete aggregate or road-base material sources. Coarse and crushed-rock aggregates which failed the abrasion test and were excluded from further testing. Fine and occasionally coarse aggregates composed of significant amounts of clay- and silt-sized particles.

AGGREGATE CHARACTERISTIC[1]			AGGREGATE USE CLASSIFICATION		
			CLASS I	CLASS II	CLASS III
ABRASION RESISTANCE, PERCENT WEAR[2]			< 50	< 50	> 50
SOUNDNESS, PERCENT LOSS[3]	COARSE AGGREGATE	Na SO_4	< 12	> 12	> 12
		Mg SO_4	< 18	> 18	> 18
	FINE AGGREGATE	Na SO_4	< 10	> 10	> 10
		Mg SO_4	< 15	> 15	> 15
POTENTIAL ALKALI REACTIVITY[4]			INNOCUOUS TO POTENTIALLY DELETERIOUS	DELETERIOUS	DELETERIOUS

1. AGGREGATE CHARACTERISTIC BASED ON STANDARD TEST RESULTS
2. ASTM C131 (500 REVOLUTIONS)
3. ASTM C88 (5 CYCLES)
4. ASTM C289

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PRELIMINARY AGGREGATE CLASSIFICATION SYSTEM VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY

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TABLE 2

Sources not specifically identified as Class I, II, or III from the three critical test results or clay- and silt-sized particle content are designated as Class II sources. All classifications are preliminary with additional field reconnaissance, testing, and case history studies needed to confirm adequacy, delimit areal boundaries, and define exact physical and chemical characteristics.

The following publications/sources were used in defining the three use classifications:

1. ASTM C33-74A Standard Specifications for Concrete Aggregate;
2. SSPWC Part II Construction Sections 200-1.1, 1.4, 1.5, and 1.7;
3. Literature applicable to concrete aggregates;
4. Industrial producers of concrete aggregates; and
5. Consultants in the field of concrete aggregates.

3.0 GEOLOGIC SETTING

3.1 PHYSIOGRAPHY

The study area lies entirely within the Great Basin physiographic subprovince (Fenneman, 1946). Primary physiographic features are controlled by block faulting which has produced uplifted north-south trending mountain ranges and intervening down-dropped alluvial basins.

Garden Valley and Coal Valley are the primary basins within the area. Garden Valley is bounded on the west by the Worthington Mountains and Quinn Canyon and Grant ranges, on the east by the Golden Gate Range, and on the south by the Timpahute Range. Coal Valley is bounded on the west by the Golden Gate Range, on the east by the Seaman Range, and on the south by the North Pahranagat Range. Part of Pahranagat Valley is located in the southern part of the mapped area. Elevations range from about 7000 to 5100 feet (2134 to 1554 m) in Garden Valley and from 6000 to 4966 feet (1829 to 1514 m) in Coal Valley.

Drainage in Garden Valley is open, generally flowing into Coal Valley through a low gap in the Golden Gate Range. Coal Valley drainage is closed to the Coal Valley playa except for an area near the southern Seaman Range where drainage is open, flowing into the White River. Shoreline features indicate Coal Valley was occupied by a Pliestocene lake to a maximum elevation of approximately 5000 feet (1524 m).

3.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Paleozoic, Mesozoic, and Cenozoic units are exposed throughout the study area. They consist predominantly of Paleozoic carbonate rocks and late Mesozoic and Cenozoic volcanic rocks exposed in the mountain ranges and late Cenozoic alluvial and lacustrine deposits exposed within the basins (Drawing 2).

Paleozoic rocks are present throughout a large portion of the area and consist of limestone and dolomite with lesser amounts of quartzite, sandstone, siltstone, and shale. Major exposures are located in the Worthington Mountains and the Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges.

Mesozoic and Cenozoic volcanic rocks are extensive within the mapped area. They consist predominantly of extrusive ash-flow and air-fall tuffs and lava flows of dacitic to rhyolitic composition. These rocks are exposed in the Quinn Canyon, Golden Gate, Seaman, North Pahranagat, and Timpahute ranges. Less extensive, late Cenozoic basaltic flows are present in the Quinn Canyon, Grant, northern Golden Gate, and Seaman ranges. Isolated intrusive volcanic rocks of dioritic to granitic composition are present in the Worthington Mountains and Quinn Canyon, Grant, and Seaman ranges.

Cenozoic alluvial deposits unconformably overlie older units and consist of alluvial fan, older lacustrine, and stream-channel and terrace deposits. Alluvial fan deposits are extensive and widespread throughout the study area. Older lacustrine

deposits are exposed predominantly in Coal Valley with some localized exposures in northern Garden Valley.

These geologic units have been grouped into eight rock units and four basin-fill units for use in discussing potential aggregate sources. Grouping of these units is based on similarities in physical and chemical properties and map-scale limitations. The resulting units allow for simplicity of discussion and presentation without altering the conclusions of this study.

3.2.1 Rock Units

Geologic rock units were grouped into the following eight categories (Drawing 2): quartzite (Qtz), limestone (Ls), dolomite (Do), carbonate rocks undifferentiated (Cau), sedimentary rocks undifferentiated (Su), granitic rocks (Gr), basalt (Vb), and volcanic rocks undifferentiated (Vu).

3.2.1.1 Quartzite - Qtz

Two quartzite units are present in the study area. They are the Ordovician Eureka Quartzite and the Mississippian Scotty Wash Quartzite. The Eureka is exposed in the Worthington Mountains and Quinn Canyon, Grant and North Pahranagat ranges. It is typically thin- to thick-bedded, fine- to medium-grained, white to light-brown vitreous orthoquartzite with interbedded sandstone and shale near the base and top of the formation. The Scotty Wash is exposed in the Seaman and Timpahute ranges. It consists of interbedded thin-bedded, yellow to dark-red quartzitic sandstone and olive-brown, gray, or red shale.

3.2.1.2 Limestone - Ls

Limestone is a carbonate rock that comprises much of the Paleozoic section. Units mapped as limestone consist of the Ordovician Pogonip Group, the Mississippian Joana Limestone, and the lower limestone member of the Pennsylvanian Ely Limestone. Mapped limestone units are present in the Worthington Mountains and Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges. They are typically hard, thin- to very thick-bedded, fine- to coarse-grained, light- to dark-gray limestone with interbedded chert, sandstone, siltstone, and shale. Locally the limestone may be dolomitic.

3.2.1.3 Dolomite - Do

Dolomite is a high magnesium carbonate rock that is found extensively within the Paleozoic section. Mapped formations include the Ordovician Ely Springs, Silurian Laketown, and Devonian Sevy and Simonson dolomites. Dolomite is exposed in all ranges within the study area except the Timpahute Range. The formations are typically medium- to thick-bedded, fine- to coarse-grained, medium- to dark-gray dolomite with interbedded chert, sandstone, siltstone, and shale.

3.2.1.4 Carbonate Rocks Undifferentiated - Cau

Undifferentiated carbonate rock units were mapped where complex, interbedded sequences of limestone and dolomite were present or where map scale prevented delineation of individual units. The Devonian Guilmette Formation is mapped as a Cau unit within

the study area. It is exposed in all ranges except the Grant and Timpahute ranges. The unit consists of medium- to thick-bedded, fine- to medium-grained, medium- to dark-gray limestone and dolomite with interbedded chert and sandstone.

Undivided Ordovician through Mississippian rocks were also mapped as undifferentiated carbonate rocks. Existing data sources do not delineate individual formations within this predominantly carbonate rock unit.

3.2.1.5 Sedimentary Rocks Undifferentiated - Su

Undifferentiated sedimentary rocks were mapped where interbedded sandstone, siltstone, shale, limestone, and/or dolomite are exposed. The highly interbedded nature of these units prevents separation into individual rock types. These units are exposed in the Quinn Canyon, Golden Gate, and Seaman ranges. Major mapped units include the Mississippian Chainman Shale and the upper sandstone member of the Ely Limestone. The shale units are typified by interbedded, variegated, thin-bedded shale and siltstone with some limestone lenses. The sandstone member of the Ely Limestone consists of fine-grained, yellowish-brown to brown calcareous sandstone with some thin beds of dark limestone.

3.2.1.6 Granitic Rocks - Gr

Granitic rocks of Tertiary age are exposed in the Worthington Mountains and Quinn Canyon, Grant, and Seaman ranges. These units are typically medium- to coarse-grained, light-gray to brownish-gray, locally porphyritic, granitic stocks and dikes.

Composition ranges from dioritic to granitic with varying amounts of quartz, feldspar, and mafic minerals.

3.2.1.7 Basalt - Vb

Basaltic flows of Tertiary age were mapped in the Quinn Canyon, Grant, northern Golden Gate, and Seaman ranges. The basalt is typically fine-grained, thin- to thick-bedded, dense, brown to black, and slightly vesicular with varying amounts of volcanic glass.

3.2.1.8 Volcanic Rocks Undifferentiated - Vu

Tertiary undifferentiated volcanic rocks comprise an extensive unit throughout the study area. This unit consists of a variety of interlayered volcanic ash-flow and air-fall tuffs and lava flows. Individual rock units have not been delineated separately because of complex lithology and map-scale limitations. Extensive exposures occur in the Quinn Canyon, Golden Gate, Seaman, North Pahranagat, and Timpahute ranges. Composition ranges from basaltic to rhyolitic but is generally dacitic to rhyolitic.

3.2.2 Basin-fill Units

Four basin-fill units were mapped within the study area (Drawing 2). They consist of older lacustrine deposits (Aol), alluvial fan deposits (Aaf), stream-channel and terrace deposits (Aal), and undifferentiated deposits (Au). Coarse (c [composed primarily of cobble-sized material]), gravel (g), and sand (s) grain-size designations (e.g., Aafg) have been assigned to

basin-fill units in the Verification mapped areas. Basin-fill units which have high silt and/or clay content are considered unsuitable aggregate sources (Class III) and will not be discussed. These units are active playas, alluvial fans, or older lacustrine deposits generally located near the valley center.

3.2.2.1 Older Lacustrine Deposits - Aol

Older lacustrine deposits are present in both Garden and Coal valleys. In northern Garden Valley, older lacustrine deposits are poorly graded, moderately well-stratified, loose- to medium-dense silty and clayey sand. Garden Valley is presently an open drainage system and the lacustrine deposits in this area are probably Tertiary in age.

In Coal Valley, older lacustrine deposits are found within much of the central valley area. These deposits are generally poorly graded, moderately well-stratified, stiff, sandy silt and clay. Along the margins of this central valley area are depositional shoreline deposits which are typically poorly graded, stratified, loose- to medium-dense gravelly sand and sandy gravel. The older lacustrine deposits in Coal Valley are probably Pleistocene in age, deposited during periods of wetter climate when a lake occupied the valley center. The maximum elevation of this lake was approximately 5000 feet (1524 m).

3.2.2.2 Alluvial Fan Deposits - Aaf

Alluvial fans are present in both basins and form the most extensive basin-fill deposits in the study area. They are

generally moderately well- to poorly graded, poorly stratified sandy gravel and gravelly sand composed of angular to subangular clasts. Alluvial fans are generally coarse-grained near the mountain front and fine-grained near the basin center. Composition of surrounding source rock strongly controls the textural properties of alluvial fan deposits. Fans derived from quartzite and carbonate rocks show a greater range of gradation (boulders to clay), whereas, fans derived from volcanic and granitic sources are predominantly sand. Caliche development (Appendix B) ranges from none to Stage III, depending on fan age, composition, and gradation.

3.2.2.3 Stream-Channel and Terrace Deposits - Aal

Stream-channel and terrace deposits are widespread throughout the study area although most are too small to depict at the 1:125,000 map scale. Mapped deposits represent significantly large ephemeral drainages and are typically poorly graded, moderately well-stratified sand with some gravel, cobbles, and boulders. Locally these units may be predominantly gravel.

3.2.2.4 Alluvial Deposits Undifferentiated - Au

Undifferentiated alluvial deposits consist of combinations of basin-fill units that were not delineated and/or mapped during the Verification program. In Coal Valley, this unit is mapped where lacustrine and alluvial deposits are intermixed and is typically poorly stratified, poorly to moderately well-graded sand. In Pahranagat Valley, this unit represents an area where detailed geologic units were not delineated during Verification.

Undifferentiated alluvial deposits in this area are unstratified to stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay derived from a variety of rock sources.

4.0 POTENTIAL AGGREGATE SOURCES

Based on the results of field visual observations and aggregate testing, potential basin-fill and rock sources were divided into three basic material types (i.e., coarse, fine, and crushed rock) and classified into one of the three use categories (Section 2.5). Basin-fill deposits tested in the study area may also be placed within a multiple-type category (coarse and fine aggregate source). Coarse aggregate (gravel to boulders) included material predominantly retained on the No. 4 sieve (0.185 inch [4.75 mm]). Fine aggregate (predominantly sand) includes material entirely passing the 3/8-inch sieve (0.375 inch [9.5 mm]), almost entirely passing the No. 4 sieve (0.187 inch [4.75 mm]), and retained on the No. 200 sieve (0.0029 inch [0.074 mm]).

Classification boundaries (Drawing 2) of basin-fill aggregate sources were generalized and will require additional studies to accurately define their location. Boundaries of identified crushed rock sources are based on the areal extent of the geologic formations tested (i.e., Eureka Quartzite, Laketown Dolomite) and not on the aggregate geologic unit (i.e., Qtz, Do) described in Section 3.2.1.

In the following, coarse aggregate sources are discussed first, followed by fine, and crushed rock sources. Within these headings, Class I is discussed first, followed by sources of successively lower potential (Class II and Class III). Sources presented within Class I and/or Class II categories are discussed

in order of their relative potential. This ranking of deposits is preliminary and based upon an analysis of Ertec and existing data.

4.1 BASIN-FILL SOURCES

4.1.1 Coarse Aggregate

4.1.1.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

Class I coarse aggregate sources are located predominantly in alluvial fan and older lacustrine deposits in Coal Valley and alluvial fan deposits in Garden Valley.

A Class I coarse aggregate source area is located along the eastern flank of the Golden Gate Range in Coal Valley within alluvial fan (Aafs) and older lacustrine shoreline (Aolg) deposits (Drawing 2). The alluvial fan deposits are moderately graded, poorly to moderately well-stratified, medium-dense to dense sandy gravel with subangular to subrounded clasts of dolomite and limestone and lesser amounts of chert and localized volcanics. Tested samples contained from 30 to 45 percent sand. The older lacustrine deposits are typically moderately well-graded, well-stratified, medium-dense sandy gravel with sub-rounded to rounded clasts of limestone and dolomite. The tested sample contained 25 percent sand-sized material. Laboratory test results show acceptable Class I standards for abrasion and soundness in both type of deposits. Potentially deleterious results for alkali reactivity were indicated in one of the alluvial fan deposit samples. Deposits in this area typically have

less than 3 feet (0.9 m) of overburden consisting of soil horizons with Stage I to II caliche development. Access and minability are generally good.

The alluvial fan deposits (Aafg) along the eastern margin of the Worthington Mountains in southern Garden Valley (Drawing 2) are considered to be a source of Class I coarse aggregates. These deposits are typically poorly to moderately well-graded, poorly to moderately well-stratified, loose to medium-dense sandy gravel with subangular clasts of dolomite and limestone. Locally, granitic clasts are present. Two samples were collected and tested. One was from an alluvial fan and the other was from an unmapped stream-channel deposit within an alluvial fan deposit. Both samples yielded Class I results for abrasion, soundness, and alkali activity (Table 2). The alluvial fan sample contained 46 percent sand, while the stream-channel sample contained less than five percent sand. Overburden ranges from 0 to 3 feet (0 to 0.9 m) and consists of poorly developed soil horizons with Stage I caliche development. Minability is good although access is presently limited.

Another Class I coarse aggregate source area is located in alluvial fan deposits (Aafg) along the western side of the northern Golden Gate Range in northeastern Garden Valley. This area consists of moderately well-graded, poorly to moderately well-stratified, medium-dense to dense sandy gravel with local areas of gravelly sand. Clasts are typically subangular to subrounded and are composed of limestone with lesser amounts of

chert and sandstone. Three tested samples, containing from 25 to 47 percent sand, indicate acceptable limits of abrasion, soundness, and alkali reactivity (only one sample was tested and was found to be innocuous). Overburden ranges from 0 to 3 feet (0 to 0.9 m) in thickness and contain soil horizons with Stage I to II caliche development. Access and minability are good to very good.

Other Class I coarse aggregate sources were identified locally within the study area in western Garden Valley, southwestern, northwestern, and eastern Coal Valley, and in Pahranagat Valley. These are shown by class and sample location in Drawing 2. All are alluvial fan deposits (Aafs, Aaf) except one stream-channel and terrace deposit (Aal). These sources are typically poorly to moderately well-graded, poorly to moderately well-stratified, loose to dense sandy gravel and gravelly sand. Laboratory tests indicate acceptable Class I results for abrasion, soundness, and, where tested, alkali reactivity. Boundaries for these units could not be drawn from the field reconnaissance and limited laboratory testing. Although additional investigations will be necessary, most deposits bordering Class I rock sources may qualify as Class I basin-fill sources.

4.1.1.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Class II coarse aggregate sources were sampled and tested in southern Garden Valley and western Coal Valley. Located in alluvial fan deposits, these sources are poorly graded, moderately well-stratified, medium dense sandy gravel and gravelly

sand. Clasts are predominantly volcanic and/or limestone in composition. Laboratory test results show acceptable abrasion and alkali reactivity (where tested) results but unacceptable soundness losses. Overburden consists of less than 3 feet (0.9 m) of poorly developed soil horizons with Stage I caliche development. Accessibility and minability are good.

Additional Class II coarse aggregate sources mapped in Drawing 2 will require further investigation to accurately delineate. Class II coarse aggregate may be located in alluvial fan (Aaf) and older lacustrine (Aol) deposits near Class I and Class II carbonate or quartzite rocks.

4.1.1.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

No unsuitable coarse aggregate sources were identified in the study area during the valley-specific investigation.

4.1.2 Fine Aggregate

4.1.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

Two Class I fine aggregate sources were identified within the study area. One is located in older lacustrine shoreline deposits (Aolg) in southwestern Coal Valley. This area is also mapped as a Class I coarse aggregate source (Section 4.1.1.1) and is therefore a multiple source (Drawing 2). This deposit consists of moderately well-graded, moderately well-stratified, medium-dense sandy gravel with subrounded to rounded clasts of limestone and dolomite. Gravel comprises 73 percent of the

of the tested sample. Laboratory tests of the fine aggregate fraction indicate acceptable standards for soundness and alkali reactivity. Overburden in this area is generally less than 3 feet (0.9 m) in thickness with Stage I caliche development. Accessibility and minability are good to very good. Boundaries of this source are placed at the limits of the gravelly older lacustrine deposit and are tenative.

The other Class I fine aggregate source is located in alluvial fan deposits (Aafs) in southwestern Coal Valley. This sample also passed Class I coarse aggregate standards (Section 4.1.1.1) and is therefore a multiple source. The source is moderately well-graded, moderately well-stratified, medium-dense to dense, sandy gravel (57 percent gravel) with subangular clasts of limestone and dolomite. Acceptable soundness results were obtained but the sample had potentially deleterious alkali reactivity results. Overburden is less than 3 feet (0.9 m) in thickness with Stage I caliche development. Accessibility and minability are good to very good. Limits of this source could not be defined.

Although no other Class I fine aggregate sources were identified from laboratory tests within the study area, field observations indicate that additional Class I fine aggregate sources may exist adjacent to Class I and/or Class II crushed rock sources.

4.1.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Widespread Class II fine aggregate sources were identified from test results in most types of basin-fill deposits (Aaf, Aol,

Aal) within the study area. Tested samples failed to meet acceptable Class I standards for soundness and/or alkali reactivity. The physical properties, composition, and source of these samples varies widely. They are typically poorly to moderately well-graded, medium-dense sandy gravel and gravelly sand composed of subangular clasts of carbonate and/or volcanic rocks. Field observations and laboratory test data for the sources are presented in Appendix A.

Class II fine aggregate sources are typically located in alluvial fan (Aaf) and older lacustrine (Aol) deposits basinward of Class I and Class II rock sources and should be available from most Class I and Class II basin-fill areas depicted in Drawing 2.

4.1.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

Class III fine aggregate sources are located in the central valley basins and are comprised predominantly of older lacustrine, recent playa, and to a lesser degree, alluvial fan and stream-channel and terrace deposits (Drawing 2). These sediments are typically interbedded, medium-dense fine sand and soft to stiff silt and clay. Locally, this mapped unit may contain appreciable sand and/or gravel in the shallow subsurface.

4.2 CRUSHED ROCK SOURCES

4.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

Class I crushed rock aggregate sources are widespread throughout the area. Major exposures are located in the Worthington

Mountains and Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges. These sources consist predominantly of Paleozoic carbonate and clastic rocks, though locally, volcanic rocks may be suitable. Mapped units consist of undifferentiated carbonate rocks (Cau) of the Guilmette Formation and undivided Ordovician through Mississippian rocks; Laketown, Sevy, and Simonson dolomites (Do); Joana and Ely limestones (Ls); Eureka Quartzite (Qtz); and localized basalt (Vb) and undifferentiated volcanic rocks (Vu).

Major exposures of the Devonian Guilmette Formation (Cau) are found in the Worthington Mountains and the Golden Gate, Seaman, and North Pahranagat ranges. The Guilmette Formation consists of hard, medium- to thick-bedded, medium-grained, light- to dark-gray limestone and dolomite with localized sandy and/or silty beds. Laboratory data from two samples indicate acceptable Class I crushed rock standards for abrasion and soundness but was not tested for alkali reactivity. Similar results were obtained in Dry Lake (FN-TR-37-a) and White River (FN-TR-37-c) valleys. Splitting characteristics are favorable for crushing. Accessibility and minability are generally very good especially along the eastern front of the Golden Gate Range.

Undivided Ordovician through Mississippian rocks (Cau) are exposed in the North Pahranagat Range. In ascending stratigraphic order, this unit consists of: Ely Springs, Laketown, Sevy, and Simonson dolomites, and the Guilmette Formation, Pilot Shale, and Joana Limestone. Because existing data have combined

these predominantly carbonate units, they are mapped as undifferentiated carbonate rocks (Cau) in Drawing 2. The majority of the units have been individually tested elsewhere and found to be Class I; therefore, the whole unit is mapped as Class I in Drawing 2. Accessability and minability are poor to good.

The Silurian Laketown Dolomite is exposed in the Worthington Mountains and Quinn Canyon, Grant, and southern Golden Gate ranges. It is typically hard, medium-grained, thin- to medium-bedded, alternating light- and dark-gray dolomite with favorable splitting characteristics. Laboratory data show favorable abrasion and soundness results. No tests for alkali reactivity were performed. Accessibility and minability are poor to good with the eastern margin of the Worthington Mountains being good to very good.

The Devonian Sevy Dolomite (Do) crops out in the Worthington Mountains and Quinn Canyon, Grant, southern Golden Gate, and North Pahranagat ranges. It is a hard, fine-grained, thin- to medium-bedded, light-gray dolomite with some interbedded sandstone near the top. Splitting characteristics are favorable and laboratory tests results meet abrasion and soundness requirements. Accessibility and minability vary, but are generally very good in the southern Golden Gate and North Pahranagat ranges.

The Devonian Simonson Dolomite (Do) was not tested within the study area but is mapped as a Class I source because of

favorable test results in nearby Dry Lake (FN-TR-37-a) and Hamlin (FN-TR-37-d) valleys. This unit is generally hard, medium- to coarse-grained, thin- to thick-bedded, light- to dark-gray dolomite. Prominant outcrops occur in the Worthington Mountains and the Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges. Splitting characteristics are generally favorable for crushing. Accessibility and minability vary with location but are generally fair to good.

The Mississippian Joana Limestone (Ls) is found predominantly in the southern Worthington Mountains and the Golden Gate, Seaman, and North Pahranagat ranges. It consists of hard, fine- to medium-grained, thin- to thick-bedded, medium- to dark-gray limestone with abundant chert in some layers. Laboratory tests show acceptable results for abrasion and soundness. Alkali reactivity was not tested. Splitting characteristics are poor to favorable but are generally more favorable in the upper part of the section. Accessability and minability are good to excellent.

The Pennsylvanian Ely Limestone (Ls) is exposed in the Golden Gate Range. Only the lower part is limestone and is discussed here. The upper part is sandstone and is discussed in Section 4.2.2. The lower Ely consists of hard, fine-grained, thin- to medium-bedded, dark-gray, weathering to light-gray limestone with interbedded sandstone and locally abundant bedded chert. Laboratory test results meet acceptable Class I requirements for abrasion and soundness. No samples were tested for alkali

reactivity. Splitting characteristics are favorable to crushing. Accessibility and minability are considered good to very good.

The Ordovician Eureka Quartzite (Qtz) is exposed in the Worthington Mountains and Quinn Canyon, Grant, and North Pahranagat ranges. It consists of hard to very-hard, fine- to medium-grained, medium- to very thick-bedded, white to light-brown vitreous orthoquartzite. Abrasion, soundness, and alkali reactivity test results indicate a Class I classification. Testing in White River Valley (FN-TR-37-c) yielded similar results. Splitting characteristics are favorable for crushing. Accessibility and minability vary throughout the study area but generally is good.

Cenozoic basalt flows (Vb) in the northern Golden Gate Range are considered Class I crushed rock aggregate sources. These basaltic rocks meet acceptable Class I standards for abrasion, soundness, and alkali reactivity. The basalt is typically thin- to thick-bedded, hard, dark-brown, fine-grained, and slightly vesicular. Splitting characteristics vary, but generally more favorable in thinly bedded areas. Accessibility and minability are very good.

An undifferentiated volcanic rock (Vu) in the Quinn Canyon Range met Class I requirements. The unit is a hard to very-hard, fine- to medium-grained, rhyodacitic ash-flow tuff. Laboratory tests yielded acceptable abrasion, soundness, and alkali reactivity results and splitting characteristics are generally

favorable. Lithologic variability of the undifferentiated volcanic rocks within the study area prevents the delineation of boundaries. Additional investigations will be necessary to define these limits.

4.2.2 Possible Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Class II crushed rock aggregate sources were identified from two sampled and tested rock types. A dioritic intrusive (Gr) in the Seaman Range and rhyodacitic ignimbrite (Vu) in the Golden Gate Range passed abrasion requirements but failed to meet Class I soundness requirements. Splitting characteristics, accessibility, and minability vary throughout the area.

The remainder of rock units mapped as Class II in Drawing 2 were classified only by field visual observations. The Ordovician Pogonip Group (Ls), Mississippian Chainman Shale (Su) and Scotty Wash Quartzite (Qtz), sandstone member of the Pennsylvanian Ely Limestone (Su), and Tertiary granitic (Gr), basaltic (Vb), and undifferentied volcanic (Vu) rocks comprise the predominant units in this class.

4.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

A rhyodacitic ignimbrite (Vu) in southern Garden Valley failed to meet Class I abrasion standards and is classified as a Class III source. The sampled rock is moderately hard, fine-grained rhyodacite. Boundaries of this source could not be drawn due to the lithologic variability of volcanic rocks. Further field

investigations will be necessary to accurately define the boundaries of this rock type.

5.0 CONCLUSIONS

Results of the valley-specific aggregate investigation indicate that sufficient supplies of potentially good- to high-quality (Class I and II) basin-fill and crushed-rock aggregate materials are available within the Garden and Coal valleys study area to meet construction requirements of the MX system (Drawing 2).

5.1 POTENTIAL BASIN-FILL AGGREGATE SOURCES

5.1.1 Coarse Aggregate

Major Class I coarse aggregate deposits, listed in order of potential suitability, have been identified within the following areas:

a. Alluvial fan (Aafs) and older lacustrine (Aolg) deposits in southwestern Coal Valley;

b. Alluvial fan deposits (Aafg) in southwestern Garden Valley; and

c. Alluvial fan deposits (Aafg) in northeastern Garden Valley.

Field observations indicate additional sources of Class I coarse aggregates may be available in alluvial fan or older lacustrine deposits adjacent to the rock/alluvium contact of Class I and/or Class II crushed rock sources.

Potentially suitable Class II coarse aggregate sources are widespread in the study area. They are typically located within alluvial fan and older lacustrine deposits flanking Class I and/or Class II rock sources.

5.1.2 Fine Aggregate

While most coarse aggregate sources will supply quantities of fine aggregate either from the natural deposits or during processing, the following Class I fine aggregate (multiple) sources were identified in:

a. Older lacustrine deposits (Aolg) in southwestern Coal Valley; and

b. Alluvial fan deposits (Aafs) in southwestern Coal Valley.

Further field reconnaissance will be required to identify and delineate additional Class I fine aggregate sources. However, based on field observations, potential sources may exist in alluvial fan deposits derived from Class I and/or Class II rock sources and unmapped older lacustrine units.

Extensive Class II fine aggregate sources are generally found basinward of most Class I and Class II rock units.

5.2 POTENTIAL CRUSHED ROCK AGGREGATE SOURCES

Class I crushed rock sources exist in most sections of the study area. The most suitable deposits and their corresponding locations are listed as follows:

a. Guilmette Formation and undivided Ordovician through Mississippian rocks (Cau) in the Worthington Mountains and Golden Gate, Seaman, and North Pahranagat ranges;

b. Laketown, Sevy, and Simonson dolomites (Do) in the Worthington Mountains and Quinn Canyon, Grant, Golden Gate, Seaman, and North Pahranagat ranges;

c. Joana and Ely limestones (Ls) in the Worthington Mountains and Golden Gate, Seaman, and North Pahranagat ranges;

d. Eureka Quartzite (Qtz) in the Worthington Mountains and Quinn Canyon, Grant, and North Pahranagat ranges; and

e. Basalt (Vb) in the northern Golden Gate Range.

Other rock units (i.e., quartzite, limestone, dolomite, and undifferentiated carbonate or sedimentary units) within the study area may provide significant quantities of Class I crushed rock. Basalt, granite, and undifferentiated volcanic or metamorphic units exhibit greater variability, but may produce localized Class I crushed-rock aggregates sources.

The majority of the rock units within the study area can be expected to meet Class II requirements. Specific Class II rock sources were found in dioritic (Gr) and rhyodacitic (Vu) rocks in the Seaman and Golden Gate ranges, respectively. One Class III rock source was identified in the Quinn Canyon Range, but further investigations will be required before specific units can be delineated.

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APPENDIX A

ERTEC WESTERN FIELD STATION AND SUPPLEMENTARY TEST DATA AND EXISTING TEST DATA SUMMARY TABLES-GARDEN AND COAL VALLEYS, NEVADA

Ertec

EXPLANATION OF ERTEC WESTERN
FIELD STATION AND SUPPLEMENTARY
TEST DATA

Ertec Western field stations were established at locations throughout the valley-specific study area where detailed descriptions of potential basin-fill or rock aggregate sources were recorded (Drawing 1). All field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Data entries record conditions at specific field station locations that have been generalized in the text and Drawing 2. Detailed explanations for the column headings in Table A-1 are as follows:

Column Heading	Explanation
Map Number	This sequentially arranged numbering system was established to facilitate the labelling of Ertec Western field station locations and existing data sites on Drawing 1 and to list the correlating information on Tables A-1 and A-2 in an orderly arrangement.
Field Station	Ertec Western field station data are comprised of information collected during: o The Valley-Specific Aggregate Resources Study; sequentially numbered field stations were completed by two investigative teams (A and B). o The general aggregate investigation in Utah (UGS). o The Verification study in Garden and Coal valleys; trench data (GN-T or CL-T) were restricted to information below the soil horizon 3 to 6 feet (1 to 2 m).
Location	Lists major physiographic or cultural features in/or near field stations or existing data in which sites are situated.

Column Heading	Explanation
Geologic Unit	Generalized basin-fill or rock geologic units at field station or existing data locations. Thirteen classifications, emphasizing age and lithologic distinctions, were developed from existing geologic maps to accommodate map scale of Drawing 2.
Material Description	Except in cases where soil or rock samples were classified on laboratory results, the descriptions are based on field visual observations utilizing the Unified Soil Classification System (see Appendix C for detailed USCS information).
Field Observations	
Boulders and/or Cobbles, Percent	The estimated percentage of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an average diameter between 3 and 12 inches (8 and 30 cm); boulders have an average diameter of 12 inches (30 cm) or more.
Gravel	Particles that will pass a 3-inch (76-mm) and are retained on No. 4 (4.75 mm) sieve.
Sand	Particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve.
Fines	Silt or clay soil particles passing No. 200.
Plasticity (Index)	Plasticity index is the range of water content, expressed as percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Field classification followed standard descriptions and their ranges are as follows: None - Nonplastic (NP) (PI, 0 - 4) Low - Slightly plastic (PI, 4 - 15) Medium - Medium plastic (PI, 15 - 30) High - Highly plastic (PI, > 31)
Hardness	A field test to identify materials that are soft or poorly bonded by estimating their resistance to impact with a rock hammer; classified as either soft, moderately hard, hard, or very hard.

Column Heading	Explanation
Weathering	Changes in color, texture, strength, chemical composition or other properties of rock outcrops or rock particles due to the action of weather; field classified as either fresh or slight(ly), moderate(ly), or very weathered.
Deleterious Materials	Substances potentially detrimental to concrete performance that may be present in aggregate; includes organic impurities, low-density material, (ash, vesicules, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche coatings, clay coatings, mica, gypsum, pyrite, chlorite, and friable materials, also, aggregate that may react chemically or be affected chemically by other external influences.
Laboratory Test Data	
Sieve Analysis (ASTM C 136)	The determination of the proportions of particles lying within certain size ranges in granular material by separation on sieves of different size openings; 3-inches, 1 1/2-inches, 3/4-inch, 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200.
No. 8, No. 16, No. 30, No. 50	*Asterisked entries used No. 10, No. 20, No. 40, and No. 60 sieves, respectively.*
Abrasion Test (ASTM C 131)	A method for testing abrasion resistance of an aggregate by placing a specified amount in a steel drum (the Los Angeles testing machine), rotating it 500 times, and determing the material worn away.
Soundness Test (ASTM C 88) CA, FA	CA = Coarse Aggregate FA = Fine Agregate The testing of aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

Column Heading	Explanation
Specific Gravity and Absorption (ASTM C 127 and 128)	Methods to determine the Bulk Specific Gravity, Bulk SSD Specific Gravity (Saturated - Surface Dry Basis), and Apparent Specific Gravity and Absorption as defined in ASTM E12-70 and ASTM C 125, respectively.
Alkali Reactivity (ASTM C 289)	This method covers chemical determination of the potential reactivity of an aggregate with alkalies in portland cement concrete as indicated by the amount of reaction during 24 hours at 80°C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 (300 m) sieve and be retained on a No. 100 (150 m) sieve.
Aggregate Use	I = Class I; potentially suitable concrete aggregate and road-base material source II = Class II; possibly unsuitable concrete aggregate/potentially suitable road-base material source III = Class III; unsuitable concrete aggregate or road base material source c = coarse aggregate f = fine aggregate f/c = fine and coarse aggregate cr = crushed rock All sources not specifically identified as Class I, II, or III from the abrasion, soundness, or alkali reactivity tests or the content of clay- and silt-sized particles, are designated as Class II sources.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
1	GN-A1	Garden Valley	Aafs	Gravelly Sand	SP	5	30	70	T
2	GN-A2	Garden Valley	Vu	Rhyodacite Ignimbrite					
3	GN-A3	Golden Gate Range	Vu	Ash-flow Tuff					
4	GN-A4	Golden Gate Range	Ls	Limestone					
5	GN-A5	Garden Valley	Vb	Basalt					
6	GN-A6	Garden Valley	Ls	Limestone					
7	GN-A7	Garden Valley	Aafs	Poorly Graded Sand	SP	0	15	80	5
8	GN-A8	Garden Valley	Ls	Limestone					
9	GN-A9	Garden Valley	Aafg	Sandy Gravel	GW-GM				
10	GN-A10	Garden Valley	Aafg	Silty Gravel	GM				
11	GN-A11	Garden Valley	Aafg	Gravelly Sand	SP-SM				
12	GN-A12	Garden Valley	Aafs	Silty Gravel	GM				
13	GN-A13	Garden Valley	Ls	Limestone					

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
30	70	T	None											
				Mod. Hard	Slight	Low Density Material								
				Mod. Hard	Mod.	Low Density Material								
				Hard	Slight	<5% Chert								
				Mod. Hard	Mod.	Low Density Material								
				Hard	Slight	30-40% Chert								
15	80	5	None			10% Chert, >50% Shale Clasts								
				Hard	Slight	Caliche, Shaly Partings								
			None			5% Chert	100	96.8	85.4	56.8	33.5	23.9	18.2	15.5
			None			5-10% Chert	97.1	92.2	77.1	61.7	49.1	42.4	36.6	31.8
			None			5% Chert	100	97.1	90.2	73.7	54.4	40.5	30.4	22.5
			None			100% Low Density Clasts	100	93.5	84.5	69.7	53.4	44.2	37.4	31.9
				Hard	Slight	5-10% Chert, Calcite Veins								

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PASSING (ASTM C 136)					ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								R (A
								COARSE AGGREGATE				FINE AGGREGATE				
								SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION	
NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA
					53.7											Potentiall Deleterio
					22.4	0.6		2.71	2.72	2.74	0.36					
18.2	15.5	13.0	10.7	8.1	33.8	8.6	19.0	2.54	2.60	2.69	2.22	2.54	2.59	2.68	2.0	Innocuou
36.6	31.8	26.3	20.4	14.1	28.0	6.7	30.3									
30.4	22.5	15.9	11.2	7.3	36.6	8.5	26.7									
37.4	31.9	25.9	19.7	13.5	46.7	22.8	23.9									Potentia Deleteri

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IVITY AND ABSORPTION 127 AND C 128)					ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
	FINE AGGREGATE						
	SPECIFIC GRAVITY			PERCENT ABSORPTION			
PERCENT ABSORPTION	BULK	BULK SSD	APPARENT		CA	FA	
							IIf/c
					Potentially Deleterious		IIIcr
							IIcr
							IIcr
							IIcr
							IIcr
							IIf/c
.36							Icr
.22	2.54	2.59	2.68	2.0	Innocuous		Ic IIf
							Ic IIf
							IIf Ic
					Potentially Deleterious	Potentially Deleterious	IIc/f
							IIcr

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
GARDEN AND COAL VALLEYS, NEVADA

2 JUL 81 | 1 OF 7 | TABLE A-1

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
14	GN-A14	Garden Valley	Aafs	Gravelly Sand	SP-SM	T	30	60	10
15	GN-A15	Garden Valley	Vu	Rhyodacite Ignimbrite					
16	GN-A16	Garden Valley	Aalg	Poorly Graded Gravel	GP				
17	GN-A17	Worthington Mountains	Do	Dolomite					
18	GN-A18	Cottonwood Creek	Aafs	Sandy Gravel	GP	30	65	35	T
19	GN-A19	Garden Valley	Aafs	Sandy Gravel	GM				
20	GN-B1	Cherry Creek	Qtz	Quartzite					
21	GN-B2	Cherry Creek	Aafs	Gravelly Sand	SP				
22	GN-B3	Garden Valley	Aafg	Sandy Gravel	GP-GM				
23	GN-B4	Garden Valley	Aafg	Sandy Gravel/ Gravelly Sand	GP/SP	T	50	50	T
24	GN-B5	Garden Valley	Vb	Andesite					
25	GN-B6	Quinn Canyon Range	Vu	Rhyodacite					

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (						
AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS							
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16
T	30	60	10	None			10-15% Chert, Shale Clasts							
					Mod. Hard	Slight to Mod.	Low Density Material							
				None			2% Chert, <5% Friable Sandstone	32.4	19.4	12.1	5.0			
					Hard	Slight	None							
30	65	35	T	None			100% Low Density Clasts							
				Low			25% Fines (Possibly Clay)		100	95.4	81.3	61.5	48.0	41.0
					Hard	Slight	Highly Fractured (Near Fault)							
				None			Caliche, Low-Density Volcanic	98.1	93.7	84.6	71.7	57.6	48.3	35.3
				None			None	100	98.0	91.3	74.6	51.5	38.0	25.0
T	50	50	T	None			Chert, Caliche							
					Hard	Slight	Vesicles, Pumice							
					Hard	Slight	Volcanic Glass, Ash, & Pumice							

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LABORATORY TEST DATA

. PERCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
								PERCENT LOSS									
NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT	
							44.1	35.3									
							25.2	1.3		2.82	2.83	2.86	0.56				
							26.2	0.8									
61.5	48.0	41.0	37.7	35.0	31.5	25.5	25.2	3.8	21.2								
							28.6	2.0									
57.6	48.3	35.3	23.1	12.6	6.4	3.9	28.6	17.4	18.8	2.37	2.46	2.59	3.60				
51.5	38.0	25.0	16.3	10.7	7.7	5.4	27.1	7.4	19.7	2.65	2.69	2.74	1.22				

D ABSORPTION D C 128) FINE AGGREGATE				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
ECIFIC GRAVITY			PERCENT ABSORPTION	CA	FA	
LK	BULK SSD	APPAR-ENT				
						IIf/c
						IIcr
				Innocuous		Ic
						Icr
						IIc/f
				Innocuous		Ic
						IIf
						Icr
						IIf
						Ic
				Innocuous	Innocuous	Ic
						IIf
						IIc/f
						IIcr
						IIcr

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
GARDEN AND COAL VALLEYS, NEVADA

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
26	GN-B7	Pine Creek	Vu	Rhyodacite					
27	GN-B8	Cottonwood Creek	Aafs	Sandy Gravel	GP				
28	GN-B9	Quinn Canyon Range	Ls	Limestone					
29	GN-B10	Golden Gate Range	Vb	Basalt					
30	WRN-B5	Garden Valley	Aafs	Sandy Gravel	GP	10	60	40	T
31	WRN-B7	Golden Gate Range	Vu	Ash-flow Tuff					
32	Cl-A1	Coal Valley	Aals	Silty Sand with Gravel	SP-SM	5	20	70	10
33	CL-A2	Coal Valley	Do	Dolomite					
34	CL-A3	Coal Valley	Aafs	Gravelly Sand	SP	T	30	70	T
35	CL-A4	Coal Valley	Aafs	Sandy Gravel	GP-GM				
36	CL-A5	Coal Valley	Aafs	Sandy Gravel	GW-GM				
37	CL-A6	Coal Valley	Aafs	Sandy Gravel	GP	T	55	45	0

	FIELD OBSERVATIONS														
	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT							SIEVE ANALYSIS, PERCENT PASSING (							
…AND/OR COBBLES PERCENT	GRAVEL	SAND	FINES	PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	N…
					Hard to Very Hard	Slight	Pumice, Glass								
				None			Low Density Volcanics	84.7	70.0	53.6	42.0	32.1	24.5	15.1	1
					Hard	Mod.	Abundant Chert								
					Hard	Slight	Vesicles, Pumice								
0	60	40	T	None			40% Low Density Volcanics, Caliche								
					Mod. Hard	Mod.	Low Density Volcanics								
5	20	70	10	None			70% Low Density Volcanics, <5% Chert								
					Hard	Mod.	None								
[illegible]	30	70	T	None			25% Low Density Volcanics								
				None			15% Low Density Volcanics	100	97.0	86.3	68.8	49.8	29.8	18.4	1
				None			Caliche	100	96.1	84.0	64.4	43.2	33.0	22.9	1
[illegible]	55	45	0	None			<5% Shale, <5% Volcanics								

LABORATORY TEST DATA

RCENT PASSING (ASTM C 136)						ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								
									COARSE AGGREGATE				FINE AGGREGATE				
									SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION	
NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		
						17.4	0.8										Pot Del
24.5	15.1	7.6	2.7	0.8	0.3	20.8	4.5	16.8									
						18.0	2.1		2.68	2.72	2.79	1.48					Inn
						20.7	0.1										
29.8	18.4	12.4	8.7	6.6	5.2	33.0	9.2	34.3	2.62	2.67	2.77	2.02					
33.0	22.9	16.7	12.9	10.3	8.1	22.9	2.5	10.9	2.80	2.83	2.87	0.95	2.70	2.74	2.81	1.46	Po Del

ND ABSORPTION ND C 128)				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FINE AGGREGATE						
PECIFIC GRAVITY			PERCENT ABSORPTION			
ULK	BULK SSD	APPAR-ENT		CA	FA	
				Potentially Deleterious		Icr
					Potentially Deleterious	Ic IIf
						IIcr
				Innocuous		Icr
						IIc/f
						IIcr
						IIf
						Icr
						IIf/c
						Ic IIf
70	2.74	2.81	1.46	Potentially Deleterious	Innocuous	Ic/f
						IIc/f

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ERTEC WESTERN FIELD STATION
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GARDEN AND COAL VALLEYS, NEVADA

2 JUL 81 3 OF 7 TABLE A-1

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
38	CL-A7	Golden Gate Range	Ls	Limestone					
39	CL-A8	Golden Gate Range	Cau	Limestone					
40	Cl-A9	Coal Valley	Aafs	Silty Gravel	GM				
41	Cl-A10	Golden Gate Range	Ls	Limestone					
42	Cl-A11	Coal Valley	Aafs	Gravelly Sand	SP-SM				
43	CL-A12	Coal Valley	Aafs	Gravelly Sand/ Sandy Gravel	SP/GP	T	50	50	0
44	CL-A13	Cold Springs Valley	Aals	Gravelly Sand	SW-SM				
45	CL-A14	Cold Springs Valley	Aafs	Gravelly Sand	SP-SM	0	20	70	10
46	CL-A15	Cold Springs Valley	Vu	Rhyodacite					
47	CL-A16	Seaman Wash	Aafs	Sandy Gravel	GP-GM	25	55	35	10
48	CL-A17	Seaman Wash	Aafs	Gravelly Sand	SW-SM				
49	CL-A18	Coal Valley	Cau	Dolomite					

ERCENT	FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (AS							
	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
					Hard	Slight	30-40% Chert (Localized)								
					Hard	Slight	Calcite Veins								
				None			5% Chert	100	90.3	74.5	57.9	43.1	35.6	29.4	24.
					Hard	Slight	5-15% Chert with Layers of 80% Chert								
				None			10% Chert 10% Low Density Volcanics		100	95.8	81.2	62.4	46.4	31.7	22.
	50	50	0	None			<5% Chert, Caliche								
				None			100% Low Density Volcanic Clasts		100	99.7	97.4	88.9	82.4	68.7	45.
	20	70	10	None			100% Low Density Volcanic Clasts								
					Mod. Hard	Mod.	Low Density Volcanics								
	55	35	10	None			50% Low Density Volcanics, 10% Silt								
				None			<5% Chert	100	91.7	81.6	66.0	46.1	37.7	29.4	22.
					Hard	Slight	Localized Chert								

LABORATORY TEST DATA

PERCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
.	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT	
.1	35.6	29.4	24.9	20.5	16.3	12.0	38.3	8.0	26.5								
.4	46.4	31.7	22.0	16.8	13.6	9.3	40.9	24.2	43.9	2.49	2.54	2.63	2.15	2.53	2.55	2.58	0.68
.9	82.4	68.7	45.1	21.8	11.3	6.4			27.4								
.1	37.7	29.4	22.8	16.1	11.4	8.8	33.6	12.0	33.0								
							18.6	0.7									

	TY AND ABSORPTION 27 AND C 128)				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
	FINE AGGREGATE						
	SPECIFIC GRAVITY			PERCENT ABSORPTION			
	BULK	BULK SSD	APPAR-ENT		CA	FA	
							IIcr
							IIcr
							Ic IIf IIcr
5	2.53	2.55	2.58	0.68			IIf/c
							IIc/f
							IIf
							IIf
							IIcr
							IIc/f
					Innocuous		IIf Ic Icr

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
50	CL-A19	Coal Valley	Aafs	Sandy Gravel	GP-GM				
51	CL-A20	Coal Valley	Aafs	Gravelly Sand	SP	T	30	65	5
52	CL-A21	Coal Valley	Aafs	Grvelly Sand	SP-SM				
53	CL-A22	Coal Valley	Aafs	Gravelly Sand	SP				
54	CL-A23	Coal Valley	Aolg	Sandy Gravel	GP				
55	CL-A24	Coal Valley	Aafs	Sandy Gravel	GW-GM				
56	CL-B1	Seaman Wash	Cau	Limestone					
57	CL-B2	Seaman Wash	Ls	Limestone					
58	CL-B3	Coal Valley	Aols	Gravelly Sand	SP-SM	0	20	70	10
59	CL-B4	Seaman Range	Gr	Dioritic Intrusive					
60	CL-B5	Seaman Range	Vu	Andesite					
61	CL-B6	Coal Valley	Aafs	Gravelly Sand	SP-SM				
62	CL-B78	Seaman Range	Cau	Limestone					
63	CL-B8	Seaman Range	Vu	Rhyolitic Ignimbrite					

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING						
AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS							
	GRAVEL	SAND	FINES					3"	1½"	¾"	[illegible]	NO. 4	NO. 8	NO. 16
				None			5-10% Chert	98.3	91.3	74.9	54.2	40.6	33.3	27.4
T	30	65	5	None			90% Low Density Volcanic Clasts							
				None			5% Chert, 40% Low Density Volcanics	100	93.7	87.5	74.7	60.1	48.9	34.6
				None			5% Chert, 50% Low Density Volcanics	100	97.5	94.0	83.8	64.4	40.9	23.9
				None			10% Chert	100	95.0	71.1	46.0	27.4	17.4	11.3
				None			<5% Chert, 10% Friable Shale	100	95.1	76.6	54.8	37.9	28.8	22.7
					Mod. Hard	Slight to Mod.	Calcite Veins							
					Hard	Slight	None							
0	20	70	10	None to Low			100% Volcanics							
					Hard	Slight to Mod.	Low Density Volcanics							
					Hard	Slight	100% Volcanics							
				None			Low Density Volcanics		100	99.5	95.1	79.3	58.8	32.7
					Hard	Slight	None							
					Mod. Hard	Slight	Glass, Ash, Pumice & Cinder							

LABORATORY TEST DATA

. PERCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
								PERCENT LOSS									
NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT	
40.6	33.3	27.4	22.5	17.5	13.6	9.9	29.8	8.4	31.6								
60.1	48.9	34.6	23.1	15.9	11.5	7.3	35.0	11.5	27.5	2.65	2.68	2.74	1.26	2.55	2.60	2.67	1.73
64.4	40.9	23.9	14.4	8.9	6.0	4.8	31.7	13.1	25.3								
27.4	17.4	11.3	8.3	5.9	4.4	2.7	29.0	3.5	12.7	2.62	2.64	2.69	1.02	2.56	2.61	2.69	1.83
37.9	28.8	22.7	18.7	14.3	10.7	7.3	27.3	4.9	20.6								
							36.0	26.5									
79.3	58.8	32.7	19.7	13.6	10.7	9.0			42.1								

IC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
EGATE		FINE AGGREGATE						
TY	PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION			
AR-NT		BULK	BULK SSD	APPAR-ENT		CA	FA	
								Ic IIf IIf/c
74	1.26	2.55	2.60	2.67	1.73	Innocuous	Potentially Deleterious	IIf Ic
						Innocuous		IIf Ic
59	1.02	2.56	2.61	2.69	1.83		Innocuous	Ic/f Ic IIf
								IIcr
								IIcr
								IIf
						Innocuous		IIcr
								IIcr
								IIf
								IIcr
								IIcr

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
GARDEN AND COAL VALLEYS, NEVADA

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
64	CL-B9	Coal Valley	Vu	Andesitic Tuff					
65	CL-B10	Seaman Range	Ls	Limestone					
66	CL-B11	Coal Valley	Aafs	Sandy Gravel	GP-GM				
67	CL-B12	Seaman Range	Ls	Limestone & Sandy Limestone					
68	CL-B13	Golden Gate Range	Cau	Limestone & Dolomite					
69	CL-B14	Coal Valley	Aafs	Sandy Gravel	GP-GM				
70	CL-B15	Coal Valley	Ls	Limestone					
71	CL-B16	Pahranagat Valley	Aal	Sandy Gravel	GP				
72	CL-B17	Pahranagat Valley	Aaf	Sandy Gravel	GP	3	55	45	T
73	CL-B18	Pahranagat Valley	Aaf	Silty Gravel	GM				
74	WRN-A10	Seaman Range	Vu	Rhyolitic Ash-Flow Tuff					
75	WRN-A11	Seaman Range	Ls	Limestone					
76	WRN-B8	Golden Gate Range	Cau	Limestone					
77	DL-A31	Pahranagat Valley	Aaf	Gravelly Sand	SP	10	45	55	T

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING						
AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS							
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16
					Hard	Slight	Volcanic Glass							
					Hard	Slight	None							
				None			None	93.1	82.8	73.1	54.2	35.1	28.5	23.6
					Hard	Slight	Chert Nodules, Shaly Partings							
					Hard	Slight	None							
				None			5% Calcite, Caliche	100	93.7	73.6	50.2	35.5	29.9	25.5
					Hard	Slight	None							
				None			12% Low Density Volcanics	98.0	93.6	77.6	52.8	32.1	19.9	13.6
3	55	45	T	None			24% Low Density Volcanics, Pumice							
				Low			None	97.6	79.9	65.0	50.9	39.0	32.4	28.1
					Hard	Slight	Volcanic Glass, Low Density Volcanics							
					Hard	Slight	Chert (80% Locally)							
					Hard	Slight	<5% Chert Beds, Some Calcite							
0	45	55	T	None			5% Chert, Caliche, Volcanic Glass							

LABORATORY TEST DATA

S, PERCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
								PERCENT LOSS									
NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT	
35.1	28.5	23.6	19.7	14.5	9.3	5.3	30.0	12.5	24.8								
35.5	29.9	25.5	22.2	18.5	13.2	8.0	24.6	6.9	26.4								
							28.9	0.6		2.66	2.69	2.74	1.06				
32.1	19.9	13.6	10.0	5.8	2.9	1.8	32.7	4.0	16.0								
39.0	32.4	28.1	25.1	21.8	16.7	12.1	27.1	2.8	16.2								
							33.3	8.5		2.67	2.69	2.71	0.65				

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GRAVITY AND ABSORPTION C 127 AND C 128)						ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
ATE		FINE AGGREGATE						
		SPECIFIC GRAVITY						
	PERCENT ABSORPTION	BULK	BULK SSD	APPAR-ENT	PERCENT ABSORPTION	CA	FA	
								IIcr
								IIcr
							Innocuous	Ic IIf IIcr
								IIcr
								Ic IIf
	1.06							Icr
								Ic IIf
								IIc/f
						Innocuous	Innocuous	Ic IIf IIcr
								IIcr
71	0.65							Icr
								IIf/c

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES PERCENT		
							GRAVEL	SAND	FINES
78	NV-H59	Grant Range	Ls	Limestone					
79	NV-H60	Golden Gate Range	Cau	Limestone					
80	NV-H61	Golden Gate Range	Ls	Limestone					
81	NV-H62	Worthington Mountains	Do	Dolomite					
82	NV-H65	Irish Mountain	Ls	Limestone					
83	CLT-4	Coal Valley	Aolf	Silty Gravel	GM				
84	CLT-10	Coal Valley	Aafs	Sandy Gravel	GW				
85	CLT-11	Coal Valley	Aolf	Gravelly Sand	SP-SM				
86	CLT-12	Coal Valley	Aolf	Sandy Silt	ML				
87	CLT-13	Coal Valley	Aafs	Gravelly Sand	SP				
88	CLT-14	Coal Valley	Aafs	Gravelly Sand	SP				

	FIELD OBSERVATIONS														
PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	SIEVE ANALYSIS, PERCENT PASSING (A							
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	N 3
					Hard	Mod.	3 - 5% Chert								
					Mod. Hard	Mod.									
					Mod. Hard	Mod.	2 - 3 % Chert								
					Hard										
					Hard	Mod.									
									100	76.0	54.6	42.2	35.9*	32.8*	31.
									100	82.9	62.1	45.0	29.1*	18.9*	12.
									100	98.4	80.2	58.0	42.6*	29.4*	18.
											100	99.9	99.7*	98.8*	97.
									100	95.4	85.4	68.3	40.4*	18.7*	5.
										100	90.2	71.3	55.4*	32.9*	21.

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LABORATORY TEST DATA

	RCENT PASSING (ASTM C 136)						ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT	
2	35.9*	32.8*	31.1*	29.6*	27.0	21.3											
0	29.1*	18.9*	12.0*	7.4*	5.5	4.4											
0	42.6*	29.4*	18.2*	10.8*	7.6	5.2											
9	99.7*	98.8*	97.4*	94.5*	80.9	52.9											
3	40.4*	18.7*	5.2*	3.2*	2.5	1.9											
3	55.4*	32.9*	21.2*	9.2*	5.1	3.2											

...C GRAVITY AND ABSORPTION (...STM C 127 AND C 128)							ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
...EGATE		FINE AGGREGATE							
...TY	PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION				
...AR- ...T		BULK	BULK SSD	APPAR-ENT			CA	FA	
									IIcr
									IIcr
									IIcr
									IIcr
									IIcr
									IIc
									IIc/f
									IIf/c
									IIIf
									IIf/c
									IIf

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2 JUL 81 7 OF 7 TABLE A-1

EXPLANATION OF EXISTING DATA

Existing data pertaining to aggregates were extracted from the State of Nevada Department of Highways. These reports are compilations of available site data from existing files and records and are intended to accurately locate, investigate, and catalog materials needed for highway construction. Explanations for column headings which appear in Table A-2, that have not been previously discussed in Table A-1, are given below:

Column Heading	Explanation
Site Number	State of Nevada Department of Highways pit or site number. Locations correspond to map numbers listed on this table and placed in Drawing 1.
Soundness Test	The testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

MAP NUMBER	SITE NUMBER	DATA SOURCE	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL			
							>6"	3-6"	1½"
89	LN15-1	Nevada Highway Department	Pahranagat Valley	Au	Sandy Gravel	GP-GM	5	10	

	SIEVE ANALYSIS															ABRASION TEST (ASTM C 131)	SOUNDNESS TEST	
	> 6"	3-6"	1½"	1"	¾"	½"	¼"	⅜"	NO. 4	NO. 10	NO. 16	NO. 40	NO 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT CA	
M	5	10			26			49							4-13	23.1		

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(ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								PLASTICITY INDEX (ASTM D 423 AND D 424)	ALKALI REACTIVITY (ASTM C 289)	
			COARSE AGGREGATE				FINE AGGREGATE						
			SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION			
CENT EAR	PERCENT LOSS		BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT			CA	FA
	CA	FA											
3.1					2.65						NP		

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EXISTING TEST DATA
GARDEN AND COAL VALLEYS, NEVADA

2 JUL 81 1 OF 1 TABLE A-3

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APPENDIX B

SUMMARY OF CALICHE DEVELOPMENT

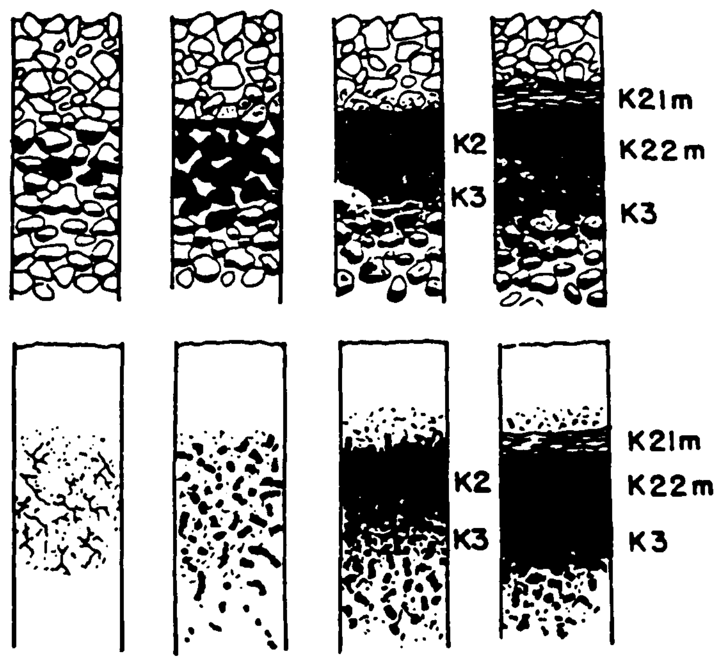
DIAGNOSTIC CARBONATE MORPHOLOGY

STAGE	GRAVELLY SOILS	NONGRAVELLY SOILS
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Laminar horizon overlying plugged horizon

STAGE	I Weak Ca	II Strong Ca	III K	IV Indurated K

GRAVELLY SOILS

NONGRAVELLY SOILS



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SUMMARY OF CALICHE DEVELOPMENT

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APPENDIX B

APPENDIX C

UNIFIED SOIL CLASSIFICATION SYSTEM

Coarse-grained soils

More than half of material is *larger* than No. 200 sieve size[b]
(The No. 200 sieve size is about the smallest particle visible to naked eye)

Major division	Subdivision	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
	Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
		Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
	Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
		Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Use grain size curve in identifying the fractions as given under field identification

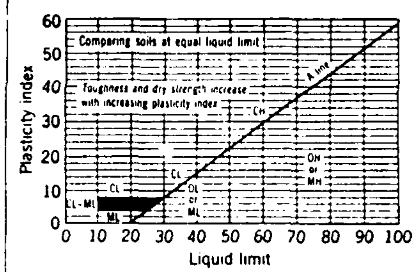
Determine percentages of gravel and sand from grain size curve
Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows:
Less than 5% *GW, GP, SW, SP*
More than 12% *GM, GC, SM, SC*
5% to 12% *Borderline* cases requiring use of dual symbols

Fine-grained soils

More than half of material is *smaller* than No. 200 sieve size
(The No. 200 sieve size is about the smallest particle visible to naked eye)

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major division	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine *sands, rock flour, silty or* clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
	Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
Silts and clays liquid limit greater than 50	Slight to *medium*	Slow to *none*	Slight to *medium*	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
	High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
	Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils	Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

From Wagner, 1957.
[a] *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.
[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately $\frac{1}{64}$ in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)
After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):
After removing particles larger than No. 40 sieve size mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
High dry strength is characteristic for clays of the CH group. A typical *inorganic silt possesses only very slight dry strength. Silty fine sands* and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):
After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During *this manipulation the moisture content is gradually reduced and the* specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action *continued until the lump crumbles.*
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

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UNIFIED SOIL CLASSIFICATION SYSTEM

2 JUL 81 APPENDIX C